Plant Resources of South-East Asia is a multivolume handbook that aims to summarize knowledge about useful plants for workers in education, research, extension and industry. The following institutions are responsible for the coordination of the Prosea Programme and the Handbook:
- Forest Research Institute of Malaysia (FRIM), Karung Berkunci 201, Jalan FRI Kepong, 52109 Kuala Lumpur, Malaysia
- Indonesian Institute of Sciences (LIPI), Widya Graha, Jalan Gatot Subroto 10, Jakarta 12710, Indonesia
- Institute of Ecology and Biological Resources (IEBR), Nghia Do, Tu Liem, Hanoi, Vietnam
- Papua New Guinea University of Technology (UNITECH), Private Mail Bag, Lae, Papua New Guinea
- Philippine Council for Agriculture, Forestry and Natural Resources Research & Development (PCARRD), Los Baños, Laguna, the Philippines
- Thailand Institute of Scientific and Technological Research (TISTR), 196 Phahonyothin Road, Bang Khen, Bangkok 10900, Thailand
- Wageningen Agricultural University (WAU), Costerweg 50, 6701 BH Wageningen, the Netherlands

In addition to the financial support of the above-mentioned coordinating institutes, this book has been made possible through the general financial support to Prosea by:
- the Finnish International Development Agency (FINNIDA)
- the Netherlands Ministry of Agriculture, Nature Management and Fisheries
- the Netherlands Ministry of Foreign Affairs, Directorate-General for International Cooperation (DGIS)
- 'Yayasan Sarana Wanajaya', Ministry of Forestry, Indonesia

Plant Resources of South-East Asia

No 8

Vegetables

J. S. Siemonsma and Kasem Piluek (Editors)

Pudoc Scientific Publishers, Wageningen 1993

DR J.S. SIEMONSMA is a tropical agronomist who graduated from Wageningen Agricultural University in 1974. He spent most of his career in project assignments in the tropics: horticultural research in Benin and Ivory Coast, research on plantation crops and food crops in Indonesia. His PhD thesis on okra (Wageningen Agricultural University, 1982) evidenced the existence of a second edible okra species in West Africa and nicely illustrates the potential benefits of more attention for tropical vegetables in the international research effort. Since 1987 he has been involved in the Prosea Programme, first as Head of the Prosea Network Office in Bogor (Indonesia) and since 1992 as Head of the Prosea Publication Office in Wageningen (the Netherlands).
DR KASEM PILUEK is a vegetable breeder who graduated from Kasetsart University, Bangkok, in 1971. Most of his career was devoted to teaching vegetable breeding and seed production at Kasetsart University, and to research on breeding of horticultural crops like Chinese cabbage, cucumber, okra and yard-long bean. His PhD thesis on Chinese cabbage (University of the Philippines at Los Baños, 1985) was based on research conducted in the tropical highlands of Thailand. He worked in close cooperation with the Asian Vegetable Research and Development Center (AVRDC) on the improvement of Chinese cabbage, and recently initiated activities on the conservation and domestication of native vegetables for the Kasetsart University Research and Development Institute. He has been a member of the Committee for Vegetable Research and Development of the National Research Council of Thailand since 1986.

Cip-Data Koninklijke Bibliotheek, Den Haag

Plant

Plant resources of South-East Asia. – Wageningen: Pudoc – Ill., map, drawings.
No. 8: Vegetables / J.S. Siemonsma and Kasem Piluek (ed.). With index, ref.
ISBN 90-220-1058-9 bound
NUGI 835
Subject headings: vegetables; South-East Asia.

ISBN 90-220-1058-9
NUGI 835

Design: Frits Stoepman GVN.

Printed in the Netherlands.

Contents

Editors and contributors

General editors of the Prosea Handbook

P.C.M. Jansen and E. Westphal

Editorial staff of this volume

- Editors: J.S. Siemonsma and Kasem Piluek
- Associate editors: G.J.H. Grubben, P.C.M. Jansen (botanical aspects), A.C. Leong, R.T. Opeña, E.T. Rasco Jr, M.H. van den Bergh and H.A.M. van der Vossen
- Illustrators: Achmad Satiri Nurhaman, Jitno Rijadi, Soejitno, Iskak Syamsudin and P. Verheij-Hayes
- Publishing consultant and in-house editor: R.J.P. Aalpol
- Language corrector: J. Burrough-Boenisch

Contributors

- L. Agustina, Faculty of Agriculture, Brawijaya University, Jalan Mayjen Haryono 163, Malang, Indonesia (*Allium chinense*)
- Anggoro H. Permadi, Lembang Horticultural Research Institute (LEHRI), P.O. Box 587, Lembang, Bandung, Indonesia (*Allium cepa* cv. group Aggregatum, *Allium sativum*)
- N. Bamroongrugsa, Faculty of Science, Prince of Songkla University, Hadyai Campus, Hadyai, Songkla 90112, Thailand (*Parkia speciosa*)
- M.M. Beltran, Institute of Plant Breeding, University of the Philippines at Los Baños, College, Laguna 4031, the Philippines (*Raphanus sativus*)
- T. Boonkerd, Department of Botany, Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand (*Coccinia grandis, Hibiscus sabdariffa, Monochoria, Solanum torvum*)
- K. Chayamarit, Royal Forest Department, Phahonyothin Road, Bang Khen, Bangkok 10900, Thailand (*Cleome gynandra, Trichosanthes*)
- S. Danimihardja, Prosea Country Office Indonesia, P.O. Box 234, Bogor 16122, Indonesia (*Solanum melongena*)
- U.A. Dasuki, Department of Biology, Bandung Institute of Technology, Jalan Ganesha 10, Bandung 40132, Indonesia (*Chrysanthemum coronarium*)
- J.M.M. Engels, International Board for Plant Genetic Resources (IBPGR), Via delle Sette Chiese 142, 00145 Rome, Italy (*Sechium edule*)
- B.H. Gildemacher, Xotus, Veenweg 115, 2631 RA Nootdorp, the Netherlands (*Cucumis sativus, Luffa, Momordica, Trichosanthes*)
- G.J.H. Grubben, Pr. Hendriklaan 24, 1404 AT Bussum, the Netherlands

(*Amaranthus, Lactuca sativa, Solanum melongena, Vigna unguiculata* cv. group Sesquipedalis, Introductory chapter)
- A.M. Gurnah, Funguni Enterprises Ltd., P.O. Box 208, Zanzibar, Tanzania (*Abelmoschus manihot, Rungia klossii*)
- E.B. Hidajat, Department of Biology, Bandung Institute of Technology, Jalan Ganesha 10, Bandung 40132, Indonesia (*Sonchus*)
- I.I.M. Huibers-Govaert, Harnjesweg 89, 6706 AS Wageningen, the Netherlands (*Rheum* ×*cultorum*)
- G.J. Jansen, Xotus, Veenweg 115, 2631 RA Nootdorp, the Netherlands (*Cucumis sativus, Luffa, Momordica, Trichosanthes*)
- P.C.M. Jansen, Prosea Publication Office, Department of Plant Taxonomy, Wageningen Agricultural University, P.O. Box 341, 6700 AH Wageningen, the Netherlands (*Brassica, Brassica oleracea, Saccharum edule, Solanum, Solanum americanum*)
- C. Jeffrey, Herbarium Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AE, England (*Sechium edule*)
- Kasem Piluek, Department of Horticulture, Faculty of Agriculture, Kasetsart University, Bang Khen, Bangkok 10900, Thailand (*Raphanus sativus*, Introductory chapter)
- T.N. Khan, Western Australian Department of Agriculture, South Perth 6151, Australia (*Psophocarpus tetragonolobus*)
- G. Kooi, Bilderdijkstraat 7-IV, 1052 NA Amsterdam, the Netherlands (*Canavalia gladiata*)
- C.G. Kuo, Asian Vegetable Research and Development Center (AVRDC), P.O. Box 42, Shanhua, Tainan 74199, Taiwan (*Brassica rapa* cv. group Chinese Cabbage)
- A.C. Leong, Malaysian Agricultural Research and Development Institute (MARDI), P.O. Box 186, Pejabat Besar Pos, 41720 Kelang, Selangor, Malaysia (*Allium cepa* cv. group Common Onion)
- U.W. Mahyar, Herbarium Bogoriense, P.O. Box 110, Bogor 16122, Indonesia (*Pilea*)
- J.O. Narciso, Institute of Plant Breeding, University of the Philippines at Los Baños, College, Laguna 4031, the Philippines (*Brassica oleracea*)
- B. Na Songkhla, Department of Botany, Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand (*Coccinia grandis, Hibiscus sabdariffa, Monochoria, Solanum torvum*)
- R.E. Nasution, Herbarium Bogoriense, P.O. Box 110, Bogor 16122, Indonesia (*Musa*)
- Nguyen Tien Ban, Institute of Ecology and Biological Resources, NCSR of Vietnam, Nghia Do, Tu Liem, Hanoi, Vietnam (*Enydra fluctuans*)
- Nguyen Tien Hiep, Institute of Ecology and Biological Resources, NCSR of Vietnam, Nghia Do, Tu Liem, Hanoi, Vietnam (*Melientha suavis, Zizania latifolia*)
- M.A. Nichols, Department of Plant Science, Massey University, Palmerston North, New Zealand (*Asparagus officinalis*)
- R.T. Opeña, Asian Vegetable Research and Development Center (AVRDC), Africa Regional Program, SADC/AVRDC Converds Secretariat, P.O. Box 10, Duluti, Arusha, Tanzania (*Brassica juncea, Brassica rapa* cv. group Caisin, *Lycopersicon esculentum*)

- L.P.A. Oyen, Prosea Publication Office, Department of Agronomy, Wageningen Agricultural University, P.O. Box 341, 6700 AH Wageningen, the Netherlands (*Allium fistulosum, Beta vulgaris, Cichorium endivia*)
- Y. Paisooksantivatana, Department of Horticulture, Faculty of Agriculture, Kasetsart University, Bang Khen, Bangkok 10900, Thailand (*Neptunia oleracea, Lycium chinense*)
- M.M. Paje, Department of Horticulture, University of the Philippines at Los Baños, College, Laguna 4031, the Philippines (*Citrullus lanatus, Cucumis melo*)
- L. Phuphatanaphong, Royal Forest Department, Phahonyothin Road, Bang Khen, Bangkok 10900, Thailand (*Luffa*)
- P. Polprasid, 21/123 Ladprao 19, Ladprao Road, Chatujak, Bangkok 10900, Thailand (*Moringa oleifera*)
- J.M. Poulos, Asian Vegetable Research and Development Center (AVRDC), P.O. Box 42, Shanhua, Tainan 74199, Taiwan (*Capsicum*)
- M. Rahmansyah, Centre for Research and Development in Biology (CRDB), P.O. Box 110, Bogor 16122, Indonesia (*Basella alba, Rorippa*)
- E.T. Rasco Jr, SAPPRAD, c/o IRRI, P.O. Box 933, Manila, the Philippines
- M.E.C. Reyes, Institute of Plant Breeding, University of the Philippines at Los Baños, College, Laguna 4031, the Philippines (*Benincasa hispida, Lagenaria siceraria, Momordica*)
- M.A. Rifai, Herbarium Bogoriense, P.O. Box 110, Bogor 16122, Indonesia (*Benincasa hispida, Erechtites, Talinum triangulare*)
- Roemantyo, Bogor Botanical Gardens, P.O. Box 110, Bogor 16122, Indonesia (*Lactuca indica, Spilanthes*)
- V.P. Roxas, Institute of Plant Breeding, University of the Philippines at Los Baños, College, Laguna 4031, the Philippines (*Cucurbita ficifolia*)
- C. Sagwansupyakorn, Department of Horticulture, Faculty of Agriculture, Kasetsart University, Bang Khen, Bangkok 10900, Thailand (*Brassica oleracea* cv. group Chinese Kale)
- E.N. Sambas, Herbarium Bogoriense, P.O. Box 110, Bogor 16122, Indonesia (*Daucus carota, Sonneratia caseolaris*)
- H. Sangat-Roemantyo, Herbarium Bogoriense, P.O. Box 110, Bogor 16122, Indonesia (*Hydrocotyle sibthorpioides*)
- D. Sasmitamihardja, Department of Biology, Bandung Institute of Technology, Jalan Ganesha 10, Bandung 40132, Indonesia (*Emilia sonchifolia, Oenanthe javanica*)
- Sayed Mohd Zain Hasan, Faculty of Agriculture, Agricultural University Malaysia (UPM), 43400 UPM, Serdang, Selangor, Malaysia (*Solanum*)
- J.S. Siemonsma, Prosea Publication Office, Department of Agronomy, Wageningen Agricultural University, P.O. Box 341, 6700 AH Wageningen, the Netherlands (*Abelmoschus esculentus, Apium graveolens, Brassica oleracea, Solanum americanum, Tetragonia tetragonioides*, Introductory chapter)
- Soenoeadji, Department of Agronomy, Faculty of Agriculture, Gadjah Mada University, Yogyakarta, Indonesia (*Allium fistulosum*)
- S. Sukprakarn, Department of Horticulture, Faculty of Agriculture, Kasetsart University, Bang Khen, Bangkok 10900, Thailand (*Cucurbita, Lactuca sativa*)

- D. Sulistiorini, Herbarium Bogoriense, P.O. Box 110, Bogor 16122, Indonesia (*Allium ampeloprasum* cv. group Leek)
- A.T. Sunarto, Centre for Research and Development in Biology (CRDB), P.O. Box 110, Bogor 16122, Indonesia (*Ocimum americanum*)
- S. Susiarti, Centre for Research and Development in Biology (CRDB), P.O. Box 110, Bogor 16122, Indonesia (*Apium graveolens, Portulaca*)
- H. Sutarno, Prosea Country Office Indonesia, P.O. Box 234, Bogor 16122, Indonesia (*Solanum melongena*)
- D.C.S. Tay, FAO Regional Office for Asia & Pacific, Maliwan Mansion, Phra Atit Road, Bangkok 10200, Thailand (*Brassica rapa* cv. group Caisin, *Brassica rapa* cv. group Pak Choi)
- W. Thephuttee, Department of Botany, Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand (*Coccinia grandis, Hibiscus sabdariffa, Monochoria, Solanum torvum*)
- H. Toxopeus, CPRO-DLO, P.O. Box 16, 6700 AA Wageningen, the Netherlands (*Brassica, Brassica rapa, Brassica rapa* cv. group Chinese Cabbage, *Brassica rapa* cv. group Pak Choi)
- M.H. van den Bergh, Department of Vegetation Science, Plant Ecology and Weed Science, Wageningen Agricultural University, Bornsesteeg 69, 6708 PD Wageningen, the Netherlands (*Chrysanthemum coronarium, Cosmos caudatus, Limnocharis flava, Sauropus androgynus,* Minor vegetables)
- Q.P. van der Meer, Prins Bernhardlaan 28, 6866 BX Heelsum, the Netherlands (*Allium ampeloprasum* cv. group Leek, *Allium cepa* cv. group Aggregatum, *Allium cepa* cv. group Common Onion, *Allium chinense, Allium sativum, Allium tuberosum*)
- H.A.M. van der Vossen, c/o International Agricultural Centre (IAC), P.O. Box 88, 6700 AB Wageningen, the Netherlands (*Brassica oleracea* cv. groups Cauliflower & Broccoli, *Brassica oleracea* cv. groups White Headed Cabbage, Red Headed Cabbage & Savoy Headed Cabbage, *Citrullus lanatus, Cucumis melo, Daucus carota, Lycopersicon esculentum, Spinacia oleracea*)
- E. Westphal, Department of Agronomy, Wageningen Agricultural University, P.O. Box 341, 6700 AH Wageningen, the Netherlands (*Ipomoea aquatica*)
- E.A. Widjaja, Herbarium Bogoriense, P.O. Box 110, Bogor 16122, Indonesia (*Cucurbita, Lagenaria siceraria, Polyscias verticillata*)
- S.H. Widodo, Department of Biology, Bandung Institute of Technology, Jalan Ganesha 10, Bandung 40132, Indonesia (*Hibiscus acetosella*)
- H. Wiriadinata, Herbarium Bogoriense, P.O. Box 110, Bogor 16122, Indonesia (*Archidendron jiringa, Parkia speciosa*)

Prosea Board of Trustees and Personnel

V.C. Fandialan, Assistant Country Officer
N.P. Gesmundo, Assistant Country Officer

Thailand

Prapandh Boonklinkajorn, Programme Leader
Soonthorn Duriyaprapan, Country Officer
Sayan Tanpanich, Assistant Country Officer

Vietnam

Nguyen Tien Ban, Programme Leader
Dzuong Duc Huyen, Country Officer
La Dinh Moi, Assistant Country Officer
Nguyen van Dzu, Assistant Country Officer

Network Office, Bogor, Indonesia

J. Kartasubrata, Head
Y.P. Manangkil, Secretary
A.J.G.H. Kostermans, Scientific Adviser
A. Suharno, Financial Officer
E. Sulistiowati, Secretary
B. Sunarno, Scientific Officer
T. Sundari, Documentation Assistant
N. Wulijarni-Soetjipto, Coordinator Regional Data Bank
Jajang, Office Assistant

Publication Office, Wageningen, the Netherlands

J.S. Siemonsma, Head
C.L. Crow, Secretary
H.C.D. de Wit, Scientific Adviser
J.M. Fundter, Forestry Officer
J.W. Hildebrand, Forestry Officer
P.C.M. Jansen, General Editor
R.H.M.J. Lemmens, Plant Taxonomy Officer
L.P.A. Oyen, Documentation Officer
M.S.M. Sosef, Plant Taxonomy Officer
E. Westphal, General Editor
W.P.M. Wolters, Programme Secretary

Foreword

Prosea volume 8 'Vegetables' bears witness of the enormous variety of plant species used as supplementary food. More than 1000 species in South-East Asia are known to yield vegetable products, but only 50 of them have developed into highly commercialized crops.

The selection of species elaborated in this volume goes beyond the coverage of existing textbooks, and is meant to counteract the fact that in the process of modernization, intensification and commercialization of the horticultural sector, attention and means are more and more focused on a small number of crops with the risk of losing track of the lesser-known species.

In the Introductory Chapter it is clearly stated that tropical vegetables, especially the lowland vegetables, have long been neglected in agricultural research. It is argued that indigenous lowland vegetables can hardly compete with the introduced highland vegetables of foreign origin, not because of a lower potential but because of the lag in research and development (high-yielding cultivars, knowledge of diseaeses and pests). The diffuse distribution and species diversity calls for a decentralization of the research effort. International institutions should support the priority crops and research topics defined by the National Agricultural Research Systems.

This new volume in the Prosea series clearly shows the importance and benefits of international cooperation. The network of Country Offices in South-East Asia played a crucial role in tracing potential authors, in collecting and checking vernacular names, in compiling national statistics on areas and production, and in scanning local literature that may not be internationally known. It is impressive to see that this approach of the Prosea network could muster so much cooperation. The list of editors and contributors shows that the information presented is very much the result of a collective effort.

Much is known about few, little is known about many. This volume may serve as a reference for national and international research and development agencies to fill in the gaps in present-day knowledge of vegetables.

Finally, I wish to express my appreciation to the board and personnel of the Prosea Foundation for making this outstanding book a reality.

Shanhua, August 1993

Dr Emil Q. Javier
Director General
Asian Vegetable Research and Development Center (AVRDC)

1 Introduction

1.1 Definition and species diversity

1.1.1 Choice of species

Vegetables form a large and diverse commodity group. They are considered a distinct group, not because they have botanical features in common, but largely because of the way in which they are grown and their produce is used. Vegetables are usually cultivated intensively in 'gardens' and consequently are part of horticulture. They are usually consumed in combination with starchy staple foods, sometimes used in small quantities to contrast with other foods in taste or to add flavour to a meal.

A vegetable as a product or commodity may be defined as a usually succulent plant or portion of a plant which is consumed as a side-dish with the starchy staple. All vegetable crops share certain common characteristics but very few completely fit any definition.

In this volume approximately 100 important vegetable species (sometimes subdivided into cultivar groups as in *Allium cepa* L., *Brassica oleracea* L. and *Brassica rapa* L.) are described in 86 papers in Chapter 2, and summary data are given on 125 minor vegetables in Chapter 3.

The selection of species is somewhat arbitrary because it is impossible to define vegetables in a way that clearly sets the boundaries with other commodity groups. Extensionists, farmers and agronomists generally group all crops in the category 'vegetables' which show similarities in cultivation methods with the familiar vegetables. For example, melon and watermelon are commonly classified as vegetables because of the resemblance to cucumber; traders and consumers, however, generally classify them as fruits. In other cases such as garlic, chives or capsicum pepper, the borderline with 'spices' is vague, and inclusion in the vegetables is a matter of convention or convenience.

The choice of species for this volume, however, is above all a function of the commodity grouping adopted for the Prosea handbook (Jansen et al., 1991). Important leguminous vegetables (French bean, kidney bean, lablab, mungbean, pea, soyabean) are not described in this volume; because the mature, dry seeds of these species are also used, they have been assigned to Prosea volume 1: 'Pulses' (1989). Immature fruits of jackfruit and papaya, and the leaves of *Gnetum gnemon* L. are important vegetables, but these species are described in Prosea volume 2: 'Edible fruits and nuts' (1991). *Sesbania grandiflora* (L.) Poiret can be found in Prosea volume 4: 'Forages' (1992). Rattans and bamboos are dealt with in volumes 6 and 7. For many root and tuber crops with vegetable uses (cassava, potato, sweet potato, taro, yam bean) reference is made to Prosea volume 9: 'Plants mainly producing carbohydrates'. *Zea mays* L., and thus vegetable maize (including baby corn, sweet corn and young corn cobs) is described in Prosea volume 10: 'Cereals', and *Centella asiatica* (L.) Urb. in Prosea volume 12: 'Medicinal plants'. Coriander and mint are included in Prosea volume 13: 'Spices'. Prosea volume 15: 'Lower plants' deals with edible fungi, ferns and other lower organisms. Many plant species other than those mentioned above yield vegetables as a by-product, though they themselves used primarily for other purposes. Approximately 800 such species are listed in Chapter 4 of this volume, with a tentative reference to the volume where more detailed information, including the vegetable aspects, can be found.

1.1.2 Domestication and introduction

It is estimated that in the course of time and on a worldwide scale, 1500–2000 plant species have been used as supplementary food. For South-East Asia, the number is close to 1000 species (Terra, 1966; Grubben, 1977; Siemonsma & Aarts-van den Bergh, 1989; Jansen et al., 1991).

Originally they were gathered from the indigenous vegetation, but soon some form of 'in-situ' protection led to primitive cultivars in at least 500 species. The most suitable ones (about 200 species) were moved closer to dwellings and cultivated in home gardens or mixed with field crops to obtain a more reliable supply for home consumption. About 80 of these 200 cultivated species proved to be sufficiently profitable for labour-intensive market-garden production. Only 20 species proved suitable for the highly intensified, protected cultivation systems as practised in western countries.

Among the 225 'primary use' vegetables described in this volume, the species cultivated for the market or for home consumption (about 120) figure prominently. Nevertheless, more than 100 wild species are described as well, including a large number of weedy companions of the field crops.

The above description of the domestication process suggests a harmonious situation with a well-balanced, well-adapted assortment of vegetables consisting of the best elements of the indigenous vegetation, as a result of a long process of selection and elimination. It may, therefore, come as a surprise that more than 80 of the 130 cultivated species have been introduced – deliberately or accidentally – into the South-East Asian region. Most of them only occur in cultivation, although some introductions from South and Central America have proven to be well adapted and have become naturalized (e.g. *Cosmos caudatus* Kunth, *Limnocharis flava* (L.) Buchenau). About 50 species from the Asian mainland and other tropical areas have crept into the region, brought along by missionaries, merchants and settlers. These vegetables have been assimilated in a gradual process during many centuries.

The colonial past led to the introduction of about 30 species of temperate origin, more or less suitable for cultivation in tropical highland areas (e.g. white cabbage). Some have succeeded in obtaining a strong position in the commercial sector in South-East Asian countries. New introductions still emerge from time to time. Popular Japanese vegetables such as 'gobo' (*Arctium lappa* L.), 'mitsuba' (*Cryptotaenia canadensis* (L.) DC.) and 'fuki' (*Petasites japonicus* (Sieb. & Zucc.) Maxim.) now occupy small niches in South-East Asian highland areas, satisfying the demand of a foreign clientele but with the potential to be assimilated by the well-to-do part of the local population as exotic vegetables with a high social value. The question arises whether one is witnessing here a harmonious addition to the assortment of vegetables in South-East Asia or the symptoms of an unequal battle between the highlands and the lowlands, between temperate and tropical vegetables.

1.1.3 Geographic distribution

From ancient times vegetables have been produced in the vicinity of human dwellings because in contrast to cereals and pulses it is difficult to transport and store these bulky and perishable products. In modern times, as a result of improved roads to consumer markets in urban centres, vegetable production areas have developed where land facilities and climatic conditions are good.

The cultivation of vegetables from temperate areas, often called 'exotic', 'European' or 'highland' vegetables, has become very widespread in the recent past. For instance, about half of the registered vegetable production in Java (Indonesia) consists of highland vegetables. These highland vegetables have partly replaced the traditional 'tropical' vegetables in local diets, especially in urban areas. Important production areas for highland vegetables can be found in Indonesia at Puncak, Sukabumi and Lembang for the urban centres of Jakarta and Bandung (West Java); at Dieng for Yogyakarta and Semarang (Central Java); at Tretes and Batu for the markets of Surabaya and Malang (East Java); further at Brastagi for the market of Medan (North Sumatra) and for export to Singapore. Similar highland vegetable production can be found in Malaysia in the Cameron Highlands, in Thailand at Chiang Mai, in the Philippines at Baguio, and in Vietnam at Dalat.

In the lowlands, large concentrated areas of vegetable production have also developed. Often these production areas are situated close to big cities, e.g. Jakarta, Surabaya, Bangkok, HoChiMinh City, and include the more traditional 'tropical' vegetable types, especially the easily perishable leafy vegetables. In some cases they are situated hundreds of kilometres from urban markets. The shallots and capsicum peppers grown in Tegal/Brebes (Central Java) are traded all over Java. However, in general the production of vegetables in the lowlands is more thinly spread over larger areas, and this impedes extension to and organization of farmers, and forms a handicap for traders.

The high productivity of temperate vegetables such as white cabbage, carrot and tomato, led to the prejudice that they are superior to indigenous species, whereas this is simply the result of prolonged and expert selection by the western-based horticultural breeding industry during a period that the research and development efforts in South-East Asian countries were still allocated to other priorities, mainly to self-sufficiency in staple foods. With the explosive development of large urban centres, these productive temperate vegetables are a convenient answer to the increased dependence on market products. However, there are disadvantages as well: they are often cultivated in environmentally sensitive areas (slopes, watersheds); their cultivation depends more heavily on fertilizers, pesticides and a seed supply from abroad; the highland vegetables are on average more expensive, and the most popular highland vegetable, i.e. white cabbage, lacks the vitamin A which makes traditional green leafy vegetables so nutritious. It is generally acknowledged that of all crop plants in the tropics, indigenous vegetables have been long neglected in agricultural research, and much remains to be done to collect and study their diversity and to improve yield and quality. This is especially true for the lowland humid tropics. Even now there is more 'adaptation' breeding work going on to try to invade the lowland areas with heat-tolerant 'highland' vegetables including Irish potato than to develop the lowland vegetables in their natural surroundings.

Advantage should be taken of the potential to grow temperate vegetables (enrichment of assortment, off-season export), but substitution and the disappearance of traditional vegetables will be regretted in the long run. The South-East Asian countries are still at the lower end of the recommended vegetable consumption. Demand for vegetables shows high income-elasticity, and with increased economic performance, demand, not least for more diversity, is expected to grow sharply. Most South-East Asians live in lowland areas, most indigenous vegetables are lowland species.

1.2 Importance of vegetables and vegetable growing

As the product of an intensive form of agriculture, vegetables are becoming increasingly important as cash crops for urban and export markets, with a great potential to improve nutrition and health of the rural and urban poor, as well as to increase their incomes and provide better employment opportunities.

Statistics on vegetable production are scarce and not very reliable. Most countries only record the acreage and production of the major commercial vegetables and ignore the many minor commercial crops and the very important part produced for home consumption. FAO statistics which are based upon country statistics are misleading in this regard. Food consumption surveys offer the clearest picture of the types and quantities consumed. A comparison between countries is also misleading because the crops or food commodities considered as 'vegetables' differ from country to country. Statistics are often based on monthly observations on planted and/or harvested area, and consequently the acreage of vegetables with repeated harvests over several months is much overestimated and the yields are underestimated when these monthly records are computed into an annual list. To give a striking example: 20 ha of kangkong which is ratooned once per month during 8 months, yielding 120 t per ratoon, may appear in the statistics as: kangkong 160 ha; 960 t (6 t/ha), which should be corrected to: kangkong 20 ha; 960 t (48 t/ha). Another problem in collecting statistics is the estimate of areas per crop in the case of mixed cropping.

Based on recent inventories for this book of a large number of urban markets in South-East Asian countries, an attempt has been made to indicate the occurrence and relative importance of all major 'primary use' vegetables described in this volume (Table 1). The most important 'secondary use' vegetables (out of the 800 listed in Chapter 4) are added at the end of the list.

1.2.1 Economic aspects

In 1989, the world production of vegetables reported by FAO (1990) was 433 940 000 t, the South-East Asian production (Indonesia, Malaysia, Papua New Guinea, the Philippines, Thailand, Vietnam) was 10 674 000 t. On a global

Table 1. Occurrence and relative importance of vegetables in urban markets in South-East Asian countries.

Major 'primary use' vegetables		Ind	Mal	PNG	Phi	Tha	Vie
Abelmoschus esculentus	: okra	1	3		4	2	3
Abelmoschus manihot	: aibika	0	0	5	0	0	0
Allium ampeloprasum cv. group Leek	: leek	1	2		0	2	2
Allium cepa cv. group Aggregatum	: shallot	5	5	5	5	5	4
Allium cepa cv. group Common Onion	: onion	2	4		5	5	3
Allium chinense	: rakkyo	1	0		0	1	0
Allium fistulosum	: welsh onion	5	1	5	4	2	3
Allium sativum	: garlic	4	4	4	5	4	4
Allium tuberosum	: Chinese chives	1	3		0	3	1
Amaranthus spp.	: amaranth	5	4	4	2	2	3
Apium graveolens	: celery	4	3		3	3	3
Archidendron jiringa	: jengkol	3	3		0	2	0
Asparagus officinalis	: asparagus	1	2		1	3	1
Basella alba	: Ceylon spinach	0	2		3	3	3
Benincasa hispida	: wax gourd	2	4		1	5	4
Beta vulgaris	: beet	2	1		2	1	2
Brassica juncea	: Indian mustard	2	4		2	5	4
Brassica oleracea cv. groups Cauliflower & Broccoli	: cauliflower, broccoli	3	3		3	5	4
Brassica oleracea cv. group Chinese Kale	: Chinese kale	1	4		1	5	3
Brassica oleracea cv. groups White, Red & Savoy Headed Cabbage	: cabbage	5	5	5	5	5	5
Brassica oleracea (other cv. groups)	: Brussels sprouts, kale, kohlrabi	0	1		0	1	3
Brassica rapa cv. group Caisin	: caisin	5	4	5	1	5	4
Brassica rapa cv. group Chinese Cabbage	: Chinese cabbage	5	4	4	5	5	4
Brassica rapa cv. group Pak Choi	: pak choi	3	4		5	2	3
Brassica rapa (other cv. groups)	: mizuna, neep greens, taatsai, turnip	1	0		0	0	0
Canavalia gladiata	: sword bean	0	0		0	0	0
Capsicum spp.	: capsicum pepper	5	5	5	4	5	4
Chrysanthemum coronarium	: garland chrysanthemum	2	3		0	3	4
Cichorium endivia	: endive	1	0		0	0	0
Citrullus lanatus	: watermelon	4	4	1	5	4	4
Cleome gynandra	: bastard mustard	0	2		0	2	0
Coccinia grandis	: ivy gourd	0	1		0	3	1
Cosmos caudatus	: cosmos	2	2		0	0	0
Cucumis melo	: melon	2	2		4	3	1
Cucumis sativus	: cucumber	5	5	5	5	5	5
Cucurbita spp.	: pumpkin, squash	4	4		5	5	5
Cucurbita ficifolia	: fig-leaf gourd	0	0		1	0	0
Daucus carota	: carrot	5	4	3	5	4	4
Emilia sonchifolia	: emilia	0	1		0	1	1
Enydra fluctuans	: buffalo spinach	0	0		0	1	1
Erechtites spp.	: pilewort	0	0		0	0	0
Hibiscus acetosella	: false roselle	1	0		0	0	0
Hibiscus sabdariffa	: roselle	0	2		0	2	0
Hydrocotyle sibthorpioides	: lawn pennywort	1	0		0	0	0

Table 1. Continued.

Major 'primary use' vegetables		Ind	Mal	PNG	Phi	Tha	Vie
Ipomoea aquatica	: kangkong	5	5	3	4	5	5
Lactuca indica	: Indian lettuce	2	2		0	0	1
Lactuca sativa	: lettuce	4	4		3	5	4
Lagenaria siceraria	: bottle gourd	3	5		5	3	4
Limnocharis flava	: sawah lettuce	2	1		0	2	1
Luffa spp.	: loofah	5	5		4	5	4
Lycium chinense	: Chinese box thorn	0	3		0	0	0
Lycopersicon esculentum	: tomato	5	5	5	5	5	5
Melientha suavis	: melientha	0	0		0	2	1
Momordica spp.	: bitter gourd	4	4		5	5	4
Monochoria spp.	: pondweed	0	0		0	0	0
Moringa oleifera	: horseradish tree	0	2		3	2	0
Musa spp.	: banana (flower)	1	1		2	3	1
Neptunia oleracea	: water mimosa	0	1		0	4	1
Ocimum americanum	: hoary basil	3	1		0	3	0
Oenanthe javanica	: water dropwort	2	2		0	1	2
Parkia speciosa	: petai	3	3		0	3	0
Pilea spp.	: pilea	1	0		0	0	0
Polyscias verticillata	: valangur	0	0	1	0	0	0
Portulaca spp.	: purslane	0	1		0	0	1
Psophocarpus tetragonolobus	: winged bean	2	2		3	2	2
Raphanus sativus	: radish	5	5		4	5	5
Rheum × *cultorum*	: rhubarb	1	1		0	0	0
Rorippa spp.	: watercress	2	3		0	1	3
Rungia klossii	: rungia	0	0	3	0	0	0
Saccharum edule	: pitpit	2	0	3	0	0	0
Sauropus androgynus	: star gooseberry	2	4		0	1	2
Sechium edule	: chayote	5	2	3	5	2	3
Solanum americanum	: glossy nightshade	2	1		1	1	0
Solanum melongena	: eggplant	5	5	3	5	5	5
Solanum torvum	: devil's fig	1	2		0	3	0
Solanum (others)	: other eggplants	0	2		0	2	1
Sonchus spp.	: sow thistle	0	0		0	0	0
Sonneratia caseolaris	: sonneratia	0	0		0	1	0
Spilanthes spp.	: spilanthes	1	0		0	2	0
Spinacia oleracea	: spinach	2	2		1	2	2
Talinum triangulare	: waterleaf	0	0		0	0	0
Tetragonia tetragonioides	: New Zealand spinach	1	0		1	0	0
Trichosanthes spp.	: snake gourd	1	2		0	3	1
Vigna unguiculata cv. group Sesquipedalis	: yard-long bean	5	5	3	5	5	5
Zizania latifolia	: wild rice	1	0		0	1	1

Table 1. Continued.

Major 'secondary use' vegetables		Ind	Mal	PNG	Phi	Tha	Vie
PROSEA 1: Pulses							
Glycine max	: soyabean	2	3		1	2	2
Lablab purpureus	: lablab	2	2		4	3	2
Phaseolus vulgaris	: french bean	5	4		4	3	5
Phaseolus vulgaris	: kidney bean	5	?		?	1	0
Pisum sativum	: pea	3	3		3	4	3
Vigna radiata	: mungbean	5	3		1	5	4
PROSEA 2: Edible fruits and nuts							
Artocarpus heterophyllus	: jackfruit	4	1		3	4	2
Carica papaya	: papaya	2	2		2	5	2
Gnetum gnemon	: melinjo	2	?		?	2	1
PROSEA 4: Forages							
Sesbania grandiflora	: sesbania	1	1		2	3	1
PROSEA 7: Bamboos							
Various species	: bamboo	4	5		4	5	4
PROSEA 9: Plants mainly producing carbohydrates							
Colocasia esculenta	: taro (leaves)	1	1		3	2	2
Ipomoea batatas	: sweet potato (leaves)	1	2	4	2	1	1
Manihot esculenta	: cassava (leaves)	4	3		0	1	1
Pachyrhizus erosus	: yambean (tubers)	3	3		4	3	4
Solanum tuberosum	: potato (tubers)	4	4	4	4	3	3
PROSEA 10: Cereals							
Zea mays	: maize (baby corn)	3	3		1	4	3
PROSEA 12: Medicinal and poisonous plants							
Centella asiatica	: centella	1	3		0	1	2
PROSEA 13: Spices							
Coriandrum sativum	: coriander	2	3		1	3	4
Mentha spp.	: mint	1	3		0	3	3
PROSEA 15: Lower plants							
Edible fungi	: mushrooms	3	3		2	4	4

0 = not observed; 1 = rare, small quantities; 5 = frequent, large quantities.

scale, production per capita per year rose during the 1980s from 78.6 to 83.4 kg, in South-East Asia it fell from 32.1 to 28.1 kg. It is a matter of considerable concern that in many tropical countries, South-East Asian countries included, vegetable production seems to be lagging behind the rate of population growth. For some countries such as the Philippines and Thailand, figures even indicate a decrease in absolute terms over the last decade. Urbanization and changes in landuse at the periphery of the big cities, and a backward market system might be the main causes of this phenomenon. In food-deficit areas in Vietnam, the difficulty of supplying minimum energy requirements through supplementary imports from food surplus areas has contributed to a strong emphasis on rice self-sufficiency. This has been accompanied by a decline in the production of other subsidiary food crops such as vegetables, which are particularly important in improving the dietary balance and variety (FAO, 1988). The FAO production estimate (kg/capita per year) for Indonesia is rather low (18.8 kg in 1989) compared with other countries in the region. This suggests the existence of an important informal production circuit (small family gardens) not covered by the FAO data. Household expenditure surveys (BPS, 1983) suggested that in 1980 the total production (and consumption) of vegetables in Indonesia was at least twice the FAO statistics.

Vegetables as a group account for 5–6% of the total value of agricultural production in South-East Asia, exceeding the value of major secondary food crops such as maize, cassava, groundnut, soyabean, sweet potato or mungbean. Although the productivity of most vegetable crops is still rather low, incomes per unit area are usually relatively high. Net revenues per hectare from shallot, pepper and tomato in Indonesia have been reported to be 3–5 times higher than those from rice.

The import and export of fresh vegetables in South-East Asia is still very limited as a percentage of total production. Trade of fresh produce between countries within the region is mainly linked to the supply of large urban centres like Singapore (e.g. cabbage from Brastagi, North Sumatra, Indonesia, and from Cameron Highlands, Malaysia), whereas there is some off-season production of temperate vegetables for the Japanese market (e.g. *Arctium lappa* L. and bulb onions from northern Thailand).

1.2.2 Nutritional aspects

Vegetables are consumed because they are tasty and healthy. They add variety and flavour to the diet. There is little chance of malnutrition occurring in families consuming enough vegetables. Vegetable consumption may, therefore, be considered as an important economic factor in a society because it improves health and working capacity. Vegetables are generally low in energy and dry matter content, but most important as sources of protective nutrients, especially vitamins and minerals. Vegetables (together with fruits) are the most important source of vitamin A, which is deficient throughout South-East Asia where rice-based diets predominate, blinding thousands of children annually (Oomen & Grubben, 1978). Although the protein content of vegetables is considered unimportant in developed countries, it appears to be highly significant in countries with an overall deficiency in proteins. Vegetables also provide fibre in the form of cellulose which aids the digestion of other foods and stimulates and cleans the intestinal canal.

The nutritive value of vegetables varies but is usually greatest in those eaten raw. In Indonesia and Malaysia, but also in other parts of the region, it is customary to eat a large variety of vegetables raw. This so-called 'lalab' or 'ulam' can also be eaten after being blanched (immersed in boiling water for several minutes), making the vegetables softer but without losing their consistency. They are often consumed in combination with a groundnut sauce or with coconut milk. Also in Chinese cuisine, vegetables are not boiled thoroughly, but usually stewed or fried in oil (strongly enhancing the availability of carotene). In New Guinea, vegetables are often wrapped in banana leaves and baked in hot ashes or between hot stones. The disadvantages of certain preparation techniques leading to overcooking can easily be overcome by slightly increased consumption, and therefore emphasis should be on averting underconsumption instead of on preparation methods.

Consumption in South-East Asia can be roughly put at 80% of the production in kg/capita per year, and (after correcting the production data for Indonesia) averages about 90 g/capita per day or 33 kg/capita per year. This compares favourably with consumption levels in Africa and South America, but is only 45% of the consumption in the developed countries. It is also much lower than the daily intake of 150 g/capita recommended by nutritionists as a target, provided that one-third of this amount derives from leafy vegetables.

A FAO/World Bank study of the agricultural and food situation in Vietnam (FAO, 1988) revealed that the nutritional status of the Vietnamese people is extremely low. Vietnam ranks among the most deprived countries in Asia. Overall there is a high prevalence of protein-energy malnutrition (PEM), endemic goitre, iron deficiency anaemia, vitamin A deficiency and other micronutrient deficiencies. The nutritional status is most severe in the northern and central coastal regions and in hilly and mountainous areas, not necessarily in areas of the highest population density.

Nutritional needs are subject to regional differences. According to FAO/WHO standards for East Asia (FAO, 1972), the average daily requirements of an adult man (55 kg) are: energy 10 600 kJ, protein 46 g, carotene (pro-vitamin A) 1.5 mg, thiamine (vitamin B_1) 1.0 mg, riboflavine (vitamin B_2) 1.5 mg, niacin 17 mg, vitamin C 30 mg, Ca 500 mg, Fe 9 mg. This information can be related to the data on the nutritional composition of individual vegetables as given in the entries in this book, but it must be stressed that the composition of foodstuffs varies widely as a result of environmental factors, varietal differences, cultural practices, harvesting stage of the plant, methods of storage, processing and preparation. Data are expressed on a fresh-weight basis, and are therefore strongly influenced by the dry-matter content.

1.2.3 Characteristics of the vegetable sector per country

The situation of vegetable production and consumption in six South-East Asian countries is outlined briefly below.

Indonesia

The Lembang Horticultural Research Institute (LEHRI) prepared a profile of the vegetable production and consumption situation of Indonesia, based upon the available statistics (van Lieshout, 1990). Production statistics are defined by the commercial production of 18 major vegetable types. The commercial production of 1988 is presented in Table 2.

Subsequently it was calculated that the total commercial area needed for the year 2000 would be 1 148 000 ha, based on the following assumptions:

- 7% annual growth of commercial demand as a consequence of population growth (2%), increase of incomes (3.5%) and urbanization (1.5%);
- 7% annual growth of commercial supply as a consequence of better technology (2%) and area enlargement (5%).

The seven most important vegetables in terms of total production in 1988 (each more than 200 000 t) were respectively cabbage, hot capsicum pepper, potato, shallot, cucumber, yard-long bean, and caisin/Chinese cabbage. The total farm gate production value was about 1250 billion Rupiah or US$ 735 million. The commercial production of 4 170 400 t mentioned in Table 2 is only 47% of the consumed quantity, which leads to the conclusion that the many non-registered commercial vegetables, each of them of minor importance, together with the numerous species for home consumption, account for 53% of total consumption.

Table 2. Supply of major commercial vegetable crops in Indonesia in 1988. Source: Lembang Horticultural Research Institute (LEHRI), Bandung, Indonesia.

Crop	Area (ha × 1000)	Yield (t/ha)	Production (t × 1000)
Capsicum spp. (hot pepper)	137.0	3.2	441.2
Vigna unguiculata (yard-long bean)	96.5	2.9	280.8
Allium cepa (shallot)	66.0	5.9	391.3
Phaseolus vulgaris (kidney bean)	51.1	1.2	62.8
Cucumis sativus (cucumber)	40.4	7.2	291.3
Solanum melongena (eggplant)	32.4	5.2	168.2
Amaranthus spp. (amaranth)	22.0	3.8	84.0
Ipomoea aquatica (kangkong)	10.4	12.8	133.2
Cucurbits (chayote, loofah, pumpkin, etc.)	4.1	42.5	172.6
Total/average lowland vegetables	459.9	4.4	2025.4
Brassica oleracea (cabbage)	44.0	18.4	809.1
Solanum tuberosum (potato)	35.7	11.5	411.1
Lycopersicon esculentum (tomato)	32.0	6.1	195.0
Brassica rapa (caisin, Chinese cabbage)	27.4	8.0	219.8
Allium fistulosum (welsh onion)	24.5	6.6	163.0
Phaseolus vulgaris (French bean)	22.6	4.7	105.4
Allium sativum (garlic)	15.9	5.6	89.5
Daucus carota (carrot)	10.5	11.8	124.3
Raphanus sativus (Chinese radish)	3.3	8.4	27.8
Total/average highland vegetables	215.9	10.4	2145.0
Total/average vegetables	675.8	6.2	4170.4

The annual export (1986: 22 900 t, mainly potato and cabbage, valued at US$ 10.4 million) and import (1986: 3400 t, mainly garlic, shallot planting material and dried hot pepper, valued at US$ 1.5 million) amount to less than 1% of the total production.
The gross intake per capita per year is 46.7 kg, which means 37.4 kg net if 20% is deducted for waste between farm gate and consumption. A daily intake of 102 g per head is reasonably high if compared with other tropical countries. But the consumption is not evenly spread. High income classes consume more vegetables than low income classes, and consumption in West Indonesia, especially West Java, is much higher than in the eastern part.
At present the production for home consumption is still very important, but it is expected that in the coming decades it will partly be replaced by commercial production. The gross urban consumption in 1990 (43.7 kg/capita) was lower than recorded in 1987 (47.7 kg/capita) whereas the gross rural consumption increased slightly (from 47.4 to 48.0 kg/capita). The most likely explanation is reduced availability in urban areas, possibly caused by an obsolete marketing system.
The data of 1990 reveal that boiled leafy vegetables (kangkong, amaranth, caisin, cabbage, cassava leaves, etc.) constitute 40% of the total quantity consumed; boiled non-leafy vegetables (yard-long bean, eggplant, chayote and other cucurbits, carrot, young kidney beans, potato, bean sprouts, young jackfruit) constitute 41%; spice vegetables (shallot, garlic, hot capsicum pepper) constitute 13% and raw (salad or 'lalab') vegetables such as cucumber and many leafy vegetables constitute 6%.

Malaysia

From the scarce statistics available it may be deduced that the range of vegetable crops lies between Thailand and Indonesia. Highland vegetables are produced in the Cameron Highlands, and lowland vegetable production is scattered everywhere in the coastal plains. The seven most important crops in acreage in Peninsular Malaysia registered in 1988 are watermelon 2400 ha, hot capsicum pepper 1400 ha, cucumber 1300 ha, cabbage 800 ha, leaf mustard 800 ha, kangkong 700 ha and amaranth 500 ha. The annual export of vegetables (mostly highland) to Singapore is considerable: about 120 000 t valued at 61 million Malaysian Ringgit or about US$ 24 million (1989). Onions, shallots and garlic are imported. No statistics are available on vegetable production for home consumption.

Papua New Guinea

The vegetable types grown in Papua New Guinea are essentially the same as those in Irian Jaya and other provinces of East Indonesia. Popular highland vegetables are garlic, potato, tomato, cabbage, carrot and welsh onion. Cucumber is very popular and is grown both in the highlands and in the lowlands. Winged bean is important for its tubers, seeds and young pods. Popular leafy vegetables are aibika, chayote tops, sweet potato tops, amaranth and rungia. There is no significant import or export of vegetables. Numerous indigenous species are collected or grown in home gardens but no statistics are available.

The Philippines

Inventories of vegetable markets in Luzon, the Philippines, give the impression that fruit vegetables (cucurbit and solanaceous fruits) are in ample supply, but that leafy vegetables play a smaller role in the diet than in other South-East Asian countries. The registered area of vegetables in 1987 was 142 348 ha (including potato and ginger, excluding dry beans and peas). The recorded production was 1 008 960 t, the average yield 7.1 t/ha. The most important vegetables in cultivated area are tomato (18 000 ha), eggplant (16 000 ha), onion and shallot (7000 ha). The most important vegetables in tonnage of yield are watermelon, tomato, eggplant, cabbage, and pumpkin. The most important fresh vegetable for export is onion (7400 t with a value of US$ 2.6 million) but many other fresh and preserved vegetables are exported.

Thailand

Two main vegetable production areas are distinguished. In the hot humid lowlands, hot-season vegetables are produced the year around. During the rainy season the types most vulnerable to heavy rains like shallot, tomato and Chinese cabbage are grown to a lesser extent. In the northern part, the cool dry winter season is suitable for the more temperate types such as cabbage, tomato, and garlic. Area, yield and production of 22 major commercial vegetable species are presented in Table 3.

The import of vegetables is insignificant, the export is becoming increasingly important. In 1989 the export of garden crop products amounted to 233 225 t with a value of 3.6 billion Bahts or US$ 144 million. The most important of the many vegetable commodities exported were baby corn and bamboo shoots. No statistics are available on vegetable production for home consumption or on consumption per commodity.

Vietnam

The Ministry of Agriculture recorded an area of 242 800 ha for vegetables in 1988 (private 208 900 ha; cooperative 33 300 ha; state 600 ha) with an average yield of 12.0 t/ha. The total production was 2 909 000 t. The projected annual growth rate for the period 1986–1990 was 6% for acreage, 2.7% for yield and 8.9% for production. However, production statistics are unreliable. Perhaps half of the vegetables for home consumption and sale in local markets are grown on private plots, not monitored by the state (FAO, 1988). There are two distinct production seasons, the 'winter' season (October – February) and the 'summer' season (April – August). Yields of vegetables reach 20 t/ha in Lam Dong and some Mekong Delta provinces, 18 t/ha in HoChiMinh City (15 000 ha) and 13–14 t/ha in Hanoi (13 000 ha). In the past, the government has taken little interest in small-scale private sector production, which receives almost no attention from research, extension or other officially-sponsored support services. Nevertheless, horticulture accounts for a large part of the value of agricultural production, consumption and cash income for farm families. Fresh or processed vegetables are a potentially important export crop. The export of fresh vegetables (cabbage, carrot, kohlrabi, cucumber, onion, cauliflower) and

Table 3. Supply of major commercial vegetable crops in Thailand in 1988. Source: Department of Agricultural Extension, Bangkok, Thailand.

Crop[1]	Area (ha × 1000)	Yield (t/ha)	Production (t × 1000)
Capsicum spp.(hot pepper/bird pepper)	120.9	2.7[2]	328
Allium sativum (garlic)	31.2	10.6	330
Allium cepa (shallot/multiplier onion)	20.9	12.9	269
Cucumis sativus (cucumber)	16.1	8.9[2]	143
Zea mays (baby corn)	13.2	6.2[2]	82
Vigna unguiculata (yard-long bean)	10.4	7.2[2]	75
Brassica oleracea (Chinese kale)	6.7	10.3	69
Brassica oleracea (cabbage)	6.3	15.4	97
Lycopersicon esculentum (tomato)	6.0	11.7[2]	70
Cucurbita spp. (pumpkin)	5.5	14.2[2]	78
Brassica rapa (pak choi)	4.5	10.2	46
Ipomoea aquatica (kangkong)	4.4	5.2[2]	23
Brassica juncea (leaf mustard)	4.4	9.8	43
Brassica rapa (Chinese cabbage)	3.6	11.7	42
Raphanus sativus (Chinese radish)	2.4	13.3	32
Allium cepa (onion)	2.2	18.6	41
Lactuca sativa (lettuce)	1.8	4.8	9
Brassica oleracea (cauliflower)	1.5	13.3	20
Benincasa hispida (wax gourd)	1.5	12.7[2]	19
Momordica charantia (bitter gourd)	1.3	5.6[2]	7
Luffa spp. (loofah)	1.1	3.6[2]	4
Pisum sativum (pea)	0.3	3.7[2]	1
Total/average	266.2	6.9	1828

1. No data given on eggplant (*Solanum melongena*).
2. Repeated harvests, area/yield data probably unreliable.

of preserved products (pickled cucumber) was about 12 000 t in 1988 (with a value of US$ 1.9 million). The export of watermelon (1988: 11 300 ton with a value of US$ 1.7 million) is as important as all other vegetables together.

Priority is given to expansion of production during the winter/spring season, especially in the Red River Delta. Input requirements and transport and marketing difficulties are the major constraints. Vegetables reportedly absorb about one-half of pesticide imports. Insecticide resistance has become a problem in the production of leafy vegetables. The major issues for vegetable production of the big cities Hanoi and HoChiMinh City are local self-sufficiency and reducing the seasonality of production. Before 1975 HoChiMinh City had only 10% of its present vegetable area and depended on shipments mainly from Dalat, 300 km away in the highlands of Lam Dong Province. This trade declined as transport deteriorated and private marketing activities were suppressed, and HoChiMinh City was forced to strive for local self-sufficiency in lowland vegetables. The cool climate of Dalat is suited for temperate-type vegetables (cabbage, kohlrabi, carrot, potato, tomato, onion, garlic, etc.) especially during the off-season (April, May, September and October). Similar opportunities exist for cool-season vegetables during the summer period in the mountainous areas north-west of Hanoi.

1.3 Botany

1.3.1 Taxonomy

The heterogeneity of the commodity group vegetables is well illustrated by the fact that the 225 species described belong to approximately 60 different plant families: vegetables occur throughout the plant kingdom. Nevertheless, some families figure prominently with respect to number of vegetable species as well as economic importance: Compositae and Cruciferae, mainly as leafy vegetables, Cucurbitaceae and Solanaceae, predominantly as fruit vegetables.

The proper naming of plants is extremely important, because it enables repeatability and use of scientific methods. Taxonomy provides such a naming service and is therefore an important biological science. Many taxonomical problems are still unsolved. Few major genera of economically important vegetable families have been revised in their entity within the last 50 years. But in genera of minor importance such as *Spilanthes* Jacquin or *Sonchus* L., the lack of linkage of data to well-defined taxa also makes much of the information useless.

The vegetables comprise some genera, *Brassica* L. in particular, showing the most bewildering array imaginable of types created by man and nature over centuries during the selection of cultivated plants. *Brassica* vegetables span a range of morphotypes comprising succulent modifications of leaves, stems, roots, buds and floral parts. Taxonomically they have been variously classified, leading to much confusion because the classic taxonomy is primarily intended for wild taxa. Closely related types were often classified as subspecies or varieties (formal classification under the International Code of Botanical Nomenclature), but the most recent approach is to distinguish cultivars and to group these in cultivar groups (the informal 'open' classification guided by the International Code of Cultivated Plants). Where workable cultivar group classifications have been developed (*Allium cepa* L., *Brassica oleracea* L., *B. rapa* L.), these are being followed or even promoted in this volume. Because of its illustrative value, the nine contributions on particular *Brassica* crops are preceded by a genus article (*Brassica* L.) outlining the taxonomic and cytogenetic basis of the present-day classification.

The taxonomy of cultivated plants is developing: as yet there is no worldwide accepted system for naming and classification, but proposals are being discussed.

1.3.2 Morphology

Vegetables are often classified according to morphological criteria such as plant parts used or growth habit. Plant parts used as vegetables comprise anything from whole leaves (kangkong, amaranth, welsh onion) to petioles (rhubarb), fruits (cucurbits, solanaceous fruits, leguminous pods), flowers (cauliflower, broccoli), stems (asparagus, bamboo shoots) and stem tubers (above-ground such as kohlrabi, or underground as in yam bean, potato), seeds (cucurbits, young leguminous seeds), storage roots (carrot, edible burdock) or bulbs, which are swollen leaf-sheaths (onion, garlic, shallot). In one case, the stem tuber is the result of a symbiosis of plant host (Manchurian wild rice) and a fungal parasite. If the 225 or so vegetable species described in this volume are classified according to plant parts used, leafy vegetables are by far the most frequent (about 60%), whereas fruit, flower, stem, root and seed vegetables account for about 15% of the species. The remaining 25% consist of multipurpose vegetables, characterized by more than one edible part. The record is probably held by the winged bean (*Psophocarpus tetragonolobus* (L.) DC.) with edible young pods, young seeds, flowers, leaves and tubers. Multipurpose vegetables may be useful for home gardens, but it should be kept in mind that the use of one part often precludes, or at least negatively affects the yield of the other; multiple use of the same plant is therefore not very common in commercial production.

In areas with cold winters, annual crops dominate the agricultural scene, but as one moves from higher latitudes towards the equator, woody perennials become more important as sources of food, and this also applies to vegetables (Cannell, 1989). About 25% of the species treated in this volume have a woody growth habit, shrubs being more frequent than trees. They play a relatively important role in home-garden production as they are a more permanent and flexible source of supplementary food, and can serve other purposes simultaneously.

1.3.3 Growth and development

Knowledge of crop growth and development and insight in the eco-physiology should help the grower to manipulate the crop and its environment so as to achieve the optimum yield of the desired plant part. Most vegetable crops do not pass through their complete life-cycle under field conditions because they are grown for their vegetative parts, or young, immature generative parts. For leaf vegetables, flowering and fruiting are to be avoided or delayed. For bulb and tuber vegetables, the formation of the storage organs is a delicate phase in the succession of growth and development processes. When flowers or fruits are the useful product, the objective is to channel as much energy to these generative plant parts. Although flowering and fruiting are often undesirable in vegetable production, the potential to complete the life-cycle is important for seed production.

Information on the growth and development of vegetables is very limited except for a number of species of temperate origin. The sequence of germination, vegetative growth, development of storage organs or generative development (flower initiation, flowering, pollination, fruiting) is highlighted in the species treatments.

1.4 Ecology

The area covered by Prosea lies between 20°N and 10°S. It consists mainly of tropical lowlands, but also has large areas at medium to high altitudes.

In agriculture, the choice of crops and cropping systems is mainly determined by interactions of ecological factors (climate, soil) and management variables.

Horticulture is an intensive form of agriculture, usually on small acreages, in which restrictions imposed by adverse climatic factors and poor soils can often be overcome by intensive management practices. Commercial vegetables are not always grown on the site and at the time which are ecologically the most appropriate, because the ultimate motive for the farmer is profit, not yield. A short distance to the market or a high price during the off-season often compensate for a lower yield or higher production costs.
In Indonesia the altitude of the production area and the distance to the city markets (transport facilities) appear to be by far the most important factors determining which species farmers choose to grow.

1.4.1 Climatic factors

Climate types

The climates of South-East Asia are of the monsoon type. Monsoons are seasonal winds blowing moist air from the sea to the heated land mass bringing heavy rains during the hot season, and blowing air from the land to the sea during the cold season. In Indonesia and Malaysia, situated close to the equator, the dry south-east trade wind from Australia causes a dry spell from May to October. This wind turns to the north above the equatorial zone and takes up much moisture above the ocean. It is known as the south-west monsoon in Thailand and neighbouring countries and causes the rainy season from May to October ('summer'). The inverse happens from December to February when the north-east monsoon causes the dry season ('winter') in Thailand but brings rain as the west monsoon in Indonesia.

Temperature

Temperature is the most important climatic factor for vegetable production. In the lowlands near the equator the average daily temperatures are generally about 27°C the year around, the differences between a hot and a cold season becoming more pronounced northwards. In northern Vietnam the average temperature from November to April is only 16°C. In these areas the summers, from May to October, are very hot and subject to typhoons.
In mountainous areas the temperature drops by about 1°C per 160 metre increase of elevation and the difference between day and night temperature broadens. The occurrence of micro-climates is quite common. Large variation in rainfall, temperature, radiation and wind may be observed between areas at relatively short distances from each other. A large part of the vegetable production is in the highlands. Since temperature is the most important factor determining the choice of vegetables that can be grown at a certain altitude and since the transition between highlands and lowlands is gradual, there is a need for a practical classification into ecological zones. An example is the empirical classification made by the Lembang Horticultural Research Institute in Java, Indonesia (Buurma & Basuki, 1989). This classification, derived from a statistical databank of 18 commercial vegetable crops, is fashioned in such a way that over 70% of the area of the typical lowland vegetables (cucumber, kangkong, yard-long bean) comes into the lowland zone and over 70% of the

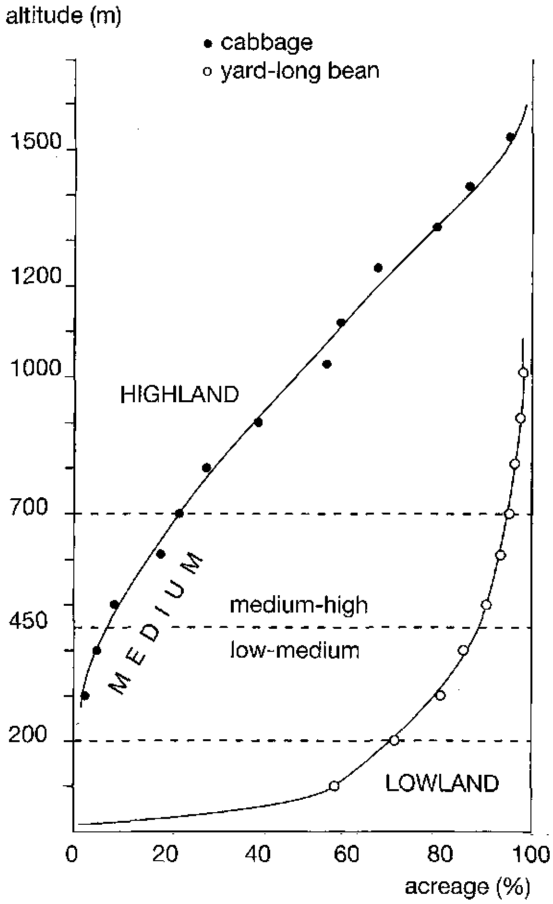


Figure 1. Horti-ecological zones for vegetable production in Java, Indonesia. Source: Buurma & Basuki, 1989.

typical highland vegetables (cabbage, carrot, potato) in the highland zone, with only a minimum of overlap in the medium elevation zone (Fig. 1). Depending on the precision desired, the classification may comprise three zones (lowland < 200 m; medium land 200–700 m; highland > 700 m), or an even finer classification into four zones by subdivision of the medium land zone into a low-medium (200–450 m) and a medium-high zone (450–700 m). This method of defining the ecological zones is useful for the interpretation of statistical data and the results of multilocational cultivar trials.

The lowland and low-medium zones of Java (below 450 m) are characterized by high maximum day temperatures (30–27°C) and night temperatures (25–22°C) and high light intensity. The main soil types are alluvial clay in the coastal plains and latosol at higher altitudes. The medium-high and highland zones (above 450 m) are characterized by maximum temperatures below 27°C, a larger variation between day and night temperature, a lower light intensity because of cloudy weather and a high air humidity. The main soil types are andosols and grumosols.

Most vegetables are dominantly present in one of the ecological zones, but they overlap. Welsh onion, red kidney beans or tomato apparently have a large optimal temperature range, since they are grown from sea-level up to high altitudes. Hot capsicum pepper is a typical lowland vegetable (79% < 450 m) but yet it occurs also in the highlands, even up to 1800 m. Typical highland cultivars of capsicum pepper do not perform well in the lowlands and vice versa. The distinction between highland and lowland cultivars, or, in the higher latitudes of northern Thailand, Philippines and Vietnam, between 'summer' (hot season) and 'winter' (cool season) cultivars is well known for some important commercial vegetables such as cauliflower, white cabbage, Chinese cabbage, tomato, and capsicum pepper.

Daylength

The variation in daylength is a less important climatic factor in the area close to the equator, but it is of increasing importance further north. At 10°N (southern part of the Philippines, Thailand and Vietnam) the daylength varies from about 11.30 h to 12.40 h and at 20°N (northern part of the Philippines, Thailand and Vietnam) from about 10.50 h to 13.20 h. The distinction between a 'summer' and a 'winter' becomes tangible above 10°N, by variations in the photoperiod and in the total daily radiation. Some crops are very sensitive to daylength variations, a nice example being okra (Siemonsma, 1982). These daylength effects will be dealt with in the species treatments.

Water

In South-East Asia vegetables can be grown year-round, provided that enough water is available. As a rule of thumb, actively growing leafy vegetables need 6 mm (6 liter per m^2) daily and other vegetables 4 mm. In the absence of rain or irrigation, the moment growth will be retarded and drought damage will occur depends on the type of crop, the soil properties and the cultural practices. In general, the yields obtained from commercial vegetable production are higher in the dry season with irrigation than in the rainy season without irrigation. The reasons for this yield depression during the rainy season are the deficient radiation by cloudy weather and the damage resulting from diseases.

1.4.2 Soil factors

Farmers are bound to a certain land area and normally have little opportunity to choose a soil type suitable for a certain crop. In general, a good soil for vegetable crops should have the following properties:

- Good structure: this means that the soil must be durably friable and stable, providing adequate water retention and aeration. A good soil is a proper medium for high microbiological activity and for undisturbed root development to a depth of at least 60 cm.
- High chemical fertility: the soil should contain reserves of essential nutrients, a sufficient amount of which must be readily available in the soil moisture. The rate of growth and production depend on the element in shortest supply ('critical element').

Ideal soil properties are identical for almost any vegetable crop. However, vegetable species and even cultivars of the same species differ in their yielding ability under adverse conditions, e.g. shallow, wet or dry, acid or saline soils. A high soil salinity (electrical conductivity > 3.0 mmho/cm) is a serious restriction for satisfactory yields of most vegetables; however, tomato, broccoli, cucumber and pumpkin are reasonably salt-tolerant. Vegetables with a shallow root system like onion, cabbage and kangkong are much more susceptible to drought than deep-rooting species like tomato, watermelon and asparagus.

Soil types

The predominant soil types in South-East Asia are andosol and latosol (both of the sandy loam type) and alluvial clays. Light soils have the advantage of easy tillage, adequate drainage and aeration, provided that the organic matter content is sufficiently high. Clay soils have the advantage of a better water-holding capacity and higher natural fertility. With good cultural practices, most vegetables will give satisfactory results on a wide range of soil types. Yet some crops such as cabbage and garlic prefer a heavy soil, whereas others like asparagus, carrot and radish prefer a light soil. Table 4 gives characteristics of two typical soil types used for vegetable production in the lowlands of Indonesia (Titulaer, 1991).

Chemical fertility

In intensive vegetable cultivation, the lack of chemical fertility is not perceived as the most serious limiting factor because amendments with manure and/or inorganic fertilizer are relatively easy. Lacking adequate recommendations, most farmers in South-East Asia rely on their own experience in the application of manure and mineral fertilizer. Unfortunately, in many cases their practice is injudicious and unbalanced, supplying too much of one element and not enough of another. Many farmers use heavy N dressings in the form of cheap

Table 4. Some characteristics of Indonesian lowland soils, i.e. latosol (Subang) and alluvial clay (Tegal). Source: Titulaer, 1991.

Soil characteristics	Latosol	Alluvial clay
colour	brown to red	bluish grey/brownish
pH-H_2O	4.4 – 5.2	7.4 – 8.4
pH-KCl	3.7 – 4.2	5.9 – 7.3
% C	1.0 – 1.5	0.6 – 1.3
% organic matter	2.0 – 3.0	1.2 – 2.6
P-Olsen, mg/kg (P_2O_5)	.	2.0 – 17.0
P-Bray, mg/kg (P_2O_5)	5.3	3.5
K_2O, mg per 100 g	32	18 – 24
CEC, me per 100 g	11 – 31	43 – 53
% base saturation	4 – 5	70 – 100

urea, which causes fast vegetative growth, making the plants susceptible to diseases and damage. Too much fertilizer means high costs of inputs and pollutes the environment. Sustainable soil conditions should be aimed at by establishing a sufficiently high level of basic fertility, and giving an appropriate fertilizer gift to compensate for the expected uptake per crop.

Soil acidity

The pH of the soil influences the availability of nutrients and also the soil structure. If the soil is very acid (pH-water < 5.5), the choice of the crop will be limited to only a very few species such as shallot or watermelon, and will certainly not be suitable for cabbage. Crops on acid soils often suffer from Mg, Ca or P deficiencies, or from Mn and Al toxicity. Liming with slakes (or preferably with dolomite) is useful at a rate of about 2 t/ha per crop until a level of pH 6–6.5 has been reached. On acid soils, it is recommended not to use too much of acidifying fertilizers such as ammonium sulphate or urea.

Physical soil properties and organic manure

The volume of an ideal soil profile consists for one-third of each of the three elements: solid mass, moisture and air. This constitution will guarantee adequate aeration, water-holding capacity, drainage and biological activity.
Organic matter has the characteristic that it reduces the compactness of heavy soils and increases the water-holding capacity of light soils. Light sandy soils should contain at least 4% organic matter, which corresponds to 2% C. For heavy clay, about 2% organic matter content (1% C) is needed. At these levels the yearly losses of organic matter are approximately 5 t/ha. This loss can be compensated by an application of about 10 t/ha of manure, but higher doses (up to 80 t/ha) are often practised for intensive vegetable production.

1.5 Agronomy

The low productivity of many vegetable crops in the tropics is largely due to the lack of research attention, aggravated by agro-economic constraints such as insufficient farm capital, inadequate transportation, and dramatic price fluctuations. Increased agronomic research attention for vegetable production translates itself into:
- knowledge of appropriate production systems;
- improved cultivars and the availability of high quality seeds;
- appropriate cultural and management techniques;
- adequate control of diseases and pests.

1.5.1 Production systems

The production systems for vegetables in South-East Asia fall into four main groups, based on land use and the level of inputs. In this section the relative importance of each of these for home consumption and for marketing is estimated and expressed as a percentage. However, in each country and region the situation will be different.

Collection of weeds and wild plants

The picking and gathering of vegetables from the wild vegetation (mostly leafy vegetables but also berries, roots, etc.) is still important in rural areas. While weeding or gathering firewood, the women often pick these edible plants (pot herbs) for the preparation of their meals at home. In the fields they also practise selective weeding, the useful weed plants being spared.
About 100 species of the 225 primary use vegetables described in this volume are weeds or wild plants. Possibly they account for about 15% of home-consumed and 5% of the marketed volume. With the increase in the population, the urbanization and the specialization in professional activities, this type of food collection will decrease further.

Home gardens

A considerable part of the vegetable production, estimated at about 30% of the home-consumed and 10% of the market vegetables, is derived from the compounds close to the houses. Annual vegetable types often encountered in the compounds are amaranth, caisin, kangkong, yard-long bean, lablab, winged bean, cucumber, bottle gourd, pumpkin, bitter gourd, chayote, capsicum pepper, eggplant, cassava (leaves). Climbing types of leguminous species or cucurbits are important because of their ability to occupy open places. However, trees and shrubs dominate the home gardens almost everywhere because they are a more permanent and more flexible source of supplementary food than annuals, they have been less successful in migrating to more commercial market gardens than herbaceous crops, and they serve many other purposes better than annual herbs such as providing shade in the compound (*Parkia speciosa* Hassk., *Archidendron jiringa* (Jack) Nielsen, *Ficus* spp.), serving as a hedge (*Sauropus androgynus* (L.) Merrill, *Polyscias* spp.), providing living support for other plants (*Moringa oleifera* Lamk), as ornamentals (*Polyscias* spp.), medicinal plants (*Gynura procumbens* (Loureiro) Merrill), or as a source of forage (*Sesbania grandiflora* (L.) Poiret) or fuelwood (*Moringa oleifera* Lamk).
Home gardens are characterized by a great diversity of useful plant species growing in a herbaceous layer near the ground, and various layers of canopies of shrubs and trees. Traditionally, home gardens in rural areas are very rich in fruits, spices and medicinal plants. Vegetables constitute a relatively modest part (in East Java about 17% of the cash value) of the home garden products, and most of these are the perennial types (Laumans et al., 1985). Also very important are the starchy tuber crops as a buffer for periods of scarcity of the main staples (mostly rice or maize). The leaves of cassava and sweet potato are important vegetables as well.
Another characteristic of the home garden is the very low input of capital (no agro-chemicals, no special tools needed, planting material at hand) and the use of cheap family labour mostly in spare time. The soil is kept fertile by the household debris and manure. In this natural biological ecosystem with its great diversity of plants, the incidence of diseases and pests is generally very low (Soemarwoto, 1985; Landauer & Brazil, 1990).
Amidst all the praise for the home garden as a cropping system whose strength lies in stability rather than peak performance, it has become clear that home

gardens are well suited to feed the family, but that commercial market gardens have to cater to the millions.

Extensive field production

The field production of vegetables for home consumption needs only a little space. It is common practice to use open places in the food crops and on field borders instead of planting entire plots with vegetables. Very common vegetables on dikes along rice fields are yard-long bean, winged bean, lablab, kangkong, amaranth, caisin, eggplant, and pumpkin.

Numerous vegetables, each usually represented by a few plants only, can be found in the fields of food crops. Hence it is a form of mixed intercropping and constitutes the vegetable part of the subsistence farm system. Not much care is given to these vegetables. They do not get separate chemical spraying or fertilizers, but may profit from the treatment given to the main crop. The great diversity of species is the best guarantee for continuous production. About 50% of the vegetables for home consumption may come from this type of vegetable production.

A considerable part of the cash crop vegetables, possibly 20%, is also produced in a very extensive way, characterized by rain-dependent production with low inputs of pesticides, fertilizers and labour and by low yield levels and poor quality with low prices. This explains the very low average yield level of many crops in national statistics, e.g. 3.2 t/ha for capsicum pepper in Indonesia. Upland fields used for the production of cash crop vegetables during the rainy season may also be planted with vegetables during the dry season, provided that sufficient irrigation water is available. Vegetables are also planted as dry season crops after rice, often on residual moisture. There is no abrupt border with the intensive production system described below; there is a gradation of intermediate cultural practices, from very extensive to very intensive.

Intensive market gardening

Intensive market gardening accounts for at least 65% of all vegetables marketed in South-East Asia. Only a very small part (5%) of the harvested products is used for own consumption. The main features of this category are the high costs for labour and inputs (seed, fertilizers, pesticides), the professional application of cultural practices and the tendency to offer improved quality products for the organized marketing sector. Within this category of intensive gardening, a distinction can be made between:

- upland vegetable production. Rainfed or irrigated vegetable crops in permanent production or in rotation with other upland food crops, e.g. maize, soyabean, groundnut, or with sugar cane.
- wet field vegetable production. Vegetable production during the dry season, after the wet season paddy, is commonest, but permanent cultivation of vegetables also occurs. The advantage of growing vegetables after rice is that soilborne diseases are eliminated by the flooding of the fields; the disadvantage is the amount of labour needed for soil tillage.

Because many vegetables are short-duration crops, they can often profitably be fitted into cropping systems based on food or industrial crops, in order to improve the cropping intensity of agricultural land. Therefore, a large proportion of the vegetables are not produced in sole cropping but in mixed intercropping. Which of these systems is chosen depends on many factors, e.g. the tradition of the farmer, the type of crops, the cost of labour, and potential for mechanization. In many cases, mixed intercropping takes the form of relay cropping, in which the growing period of a younger and an older crop, or of a long-duration and a short-life crop overlap. Farmers use mixed intercropping instead of sole cropping for economic reasons in order to:

- reduce the risk of losses. If one crop fails, the second or third crop growing at the same time in the same field may give a profit.
- make better use of the land. Young plants do not cover the land area completely and the sunlight is underutilized. Intercropping with other plants traps the available light as efficiently as possible. Relay cropping shortens the time in between harvests. A good example is capsicum pepper in Indonesia, planted on thousands of hectares in between shallots one month before the shallots are harvested.
- economize on production inputs (fertilizers, pesticides). Cabbage and capsicum pepper are planted between tomato and they profit from the pesticides and fertilizers applied to tomato.

Several other advantages from the agronomical and environmental point of view can be mentioned:

- pathogens, pest populations (thrips, aphids, mites etc.) and virus infections may be kept at a lower level, perhaps below the damage threshold. Tomato plants repel diamond-back moth in cabbage. Maize plants give protection to the predators (natural enemies) of pests of capsicum pepper.
- the dense vegetation in mixed intercropping reduces soil erosion by heavy rainfall.
- minerals are better used and leaching is reduced.
- weeds are suppressed.
- bamboo or wooden poles for tomato or cucumber are used again by other climbing vegetables (loofah, bitter gourd, beans).
- the shade of the earlier crop (maize) is profitable for younger crops such as capsicum pepper.

But mixed intercropping certainly also has disadvantages:

- spraying with pesticides is no longer selective. Farmers use wide spectrum pesticides, they spray routine-wise and do not respect the safety period needed before harvesting the earliest species in the mixture.
- crop rotation for reduction of soilborne diseases and pests is difficult. In Java a common relay-cropping system lasting one year is tomato/cabbage (white or Chinese); harvested cabbage is replaced by capsicum pepper, French bean is planted against tomato sticks. In this system, the soilborne diseases club root, bacterial wilt and root-knot nematodes will be maintained.
- manual and mechanized weed control are difficult.

Farmers know by experience which crops combine well. They combine plants with a certain tolerance of shade (capsicum pepper, welsh onion, Chinese cabbage) with tall crops (maize) or climbing species (leguminous vegetables, cucurbits). However, farmers have less knowledge of the crop rotation required to avoid soilborne diseases.

Some of the woody species in the vegetable assortment may have a role to play in agroforestry systems. This is a relevant possibility since an important issue for the future is how to combine agriculture and forestry in order to achieve sustained production of food, fuel and timber.

1.5.2 Planting materials

Although the use of improved commercial seed is rapidly increasing in South-East Asia, a large part of the marketed vegetables is harvested from crops of local cultivars, landraces or farmers' selections. Self-pollinated crops (e.g. tomato) breed true to type and the grower can easily obtain next season's sowing seed from a limited number of healthy plants. Maintaining the identity of cross-pollinated crops (hot pepper, cucurbits) is more complicated. The grower has to remove plants that are off-types in an early stage and he then has to take the seed from the best plants in the middle of his field. If homogeneity is really important for the grower then he could better leave the seed production to the professional seed growers.

The lack of modern selected cultivars and of an efficient seed supply system is a serious hindrance to the improvement of commercial vegetable cultivation. In most South-East Asian countries a local seed industry is gradually emerging, and a start has been made to establish independent official control of the genetic integrity and physical quality of vegetable seeds. Imported seeds of European-type vegetables are not usually adapted to tropical conditions and are often inadequately protected from the effects of high temperatures and humidity.

If the private sector is to invest in the development of improved cultivars, the crops concerned must cover sufficient area and it must be possible to cover the costs of development; seed firms therefore try to develop and market F_1 hybrid cultivars, whose seed has to be renewed each season unless the lower yields through inbreeding depression in successive generations are accepted.

A great advantage of hybrid cultivars is that the period required to combine useful characters, e.g. for resistance to disease, is much shorter than in conventional cultivars. The creation of hybrid cultivars is relatively easy, especially in the case of solanaceous vegetables and cucurbits. Because the hybrid seed is so expensive, farmers often harvest the seed from their F_1 hybrid crop for the next planting, but their experience with the segregating F_2 hybrid material is in most cases very frustrating. The inbreeding depression is reflected in a lower yield and loss of uniformity and quality. In some cases this depression is relatively slight, e.g. for certain hybrids of onion, tomato, capsicum pepper. In watermelon the depression is so large that the product of the F_2 is no longer marketable.

Modern seed companies strive to bring a complete assortment of vegetable seeds of the region into the seed merchants. This includes the many OPs, i.e. the open-pollinated cultivars which might easily be reproduced by the farmers themselves. In practice, however, farmers gradually realize that it pays to buy all seed from a dealer, provided that the price is reasonable (Groot et al., 1988). The production of healthy and viable seed which is true-to-type is a skilled business.

The vegetatively propagated crops (garlic, shallot) are less attractive for seed companies because it is easy for the farmer himself to renew the expensive

planting material. Yet for these crops too, professional seed producers will gradually take over from the farmers because they will supply superior virus-free planting material. For vegetatively propagated vegetables like aibika, the kangkong type reproduced by cuttings and star gooseberry, farmers must rely on their own planting material.
Table 5 gives some data on the seed of commercial vegetables.

1.5.3 Husbandry

In the future crop husbandry will have to concentrate on the efficient use of resources and approaches to recycling. Better agronomic practices can reduce soil erosion and lower chemical inputs. Because of the high value of vegetable crops and their adaptability to different cropping systems, manuring and recycling of plant nutrients can be promoted.
Fertilizer recommendations can be arrived at in two ways:

- Soil analyses combined with field trials result in response curves for macronutrients. If the farmer has soil samples analysed before planting, these curves can be used to translate soil analysis data into precise recommendations for his own field, but this seldom occurs. Normally, these data are used by agronomists and extensionists to prepare general average recommendations for the farmers, taking the soil and crop type into consideration but not the condition of the specific field. Table 6 gives a valuation of soil analysis data.
- Plant analyses and yield data give information about the amounts of nutrients taken up by the crop. The best indication gives the analysis of the total biomass of the harvested plant parts (removal of nutrients) and the plant parts remaining in the field (temporarily immobilized nutrients), the total being the nutrient uptake of the crop. Some examples of the uptake of macronutrients are presented in Table 7.

Assuming that the non-harvested plant parts will remain in the field, it still must be realized that the uptake or absorption, and thus immobilization, of minerals is much greater than the actual removal from the field in the harvested part. The uptake of minerals seems to vary greatly between species, but there is much conformity for crops within the same species. Variations are caused by growing conditions, varietal differences and soil properties. A higher than normal uptake (luxury consumption) is caused by too high a supply, e.g. of N or K.
In practice, the yield expected from a good crop under local conditions is often taken as criterion for a calculation of the fertilizer recommendation. When estimating the adequate fertilizer gift based upon the amounts taken up, losses by leaching or immobilization have to be compensated for. For example, it has been found that the uptake of a shallot crop producing 15 t/ha of bulbs in Indonesia was 80 kg N, 15 kg P (35 kg P_2O_5) and 90 kg K (105 kg K_2O). The recovery (utilization rate, efficiency factor) was estimated at respectively 60%, 40% and 70% of the nitrogen, phosphate and potassium fertilizer, leading to a recommendation of 80/0.6 = 130 kg N, 35/0.4 = 90 kg P_2O_5 and 105/0.7 = 150 kg K_2O.
Usually, skilled vegetable farmers apply manure, compost or other organic fertilizer whenever it is available, in quantities from 10–30 t/ha or more. Apart

Table 5. Data on seed production of vegetable crops in South-East Asia. Source: Grubben, 1978 (adapted).

Vegetable type	Variety type[1]	Sowing method	Number of seeds/g	Seed needed per ha[2]	Pollination	Potential seed yield (kg/ha)[3]
Allium crops						
garlic	clone	direct	cloves	600 kg	–	8 000
leek	OP	nursery	400	3 kg	insects	600
onion	OP	direct	350	4 kg	insects	600
onion	hybrid	nursery	350	3 kg	artificial	400
shallot	clone	direct	bulbs	1000 kg	–	18 000
welsh onion	OP	nursery	350	3 kg	insects	400
welsh onion	clone	direct	shoots	200 000	–	1 000 000 sh
Cruciferous crops						
cabbage	OP	nursery	300	300 g	artificial	400
caisin,pak choi	OP	direct	300	1 kg	insects	1 000
cauliflower, broccoli	OP	nursery	300	400 g	insects	600
cauliflower, broccoli	hybrid	nursery	300	300 g	insects	400
Chinese cabbage	hybrid	nursery	300	400 g	artificial	600
Chinese kale	OP	direct	300	20 kg	insects	600
radish	OP	direct	100	5 kg	insects	1 000
Cucurbits						
bitter gourd	OP	direct	17	5 kg	insects	500
bitter gourd	hybrid	nursery	17	1.5 kg	artifical	200
bottle gourd	OP	direct	7	3 kg	insects	600
chayote	clone	direct	fruits	–	–	200 000 fr
cucumber	OP	direct	40	3 kg	insects	600
cucumber	hybrid	nursery	40	1 kg	artificial	300
loofah	OP	direct	11	5 kg	insects	500
loofah	hybrid	nursery	11	1.5 kg	artificial	200
melon	OP	direct	40	2 kg	insects	300
melon	hybrid	nursery	40	1 kg	artificial	100
pumpkin	OP	direct	6	2 kg	insects	500
watermelon	OP	direct	14	2 kg	insects	300
watermelon	hybrid	nursery	14	1 kg	artificial	150
wax gourd	OP	direct	14	2 kg	insects	400
Leguminous crops						
French bean	OP	direct	4	100 kg	self	1 200
lablab	OP	direct	3	40 kg	self	1 500
kidney bean	OP	direct	3	60 kg	self	1 800
lima bean	OP	direct	2	20 kg	self	2 000
sword bean	OP	direct	0.3	60 kg	self/insects	2 000
winged bean	OP	direct	2	30 kg	self	1 500
yard-long bean	OP	direct	4	20 kg	self	1 000

Table 5. Continued.

Vegetable type	Variety type[1]	Sowing method	Number of seeds/g	Seed needed per ha[2]	Pollination	Potential seed yield (kg/ha)[3]
Solanaceous crops						
eggplant	OP	nursery	250	150 g	insects/self	200
eggplant	hybrid	nursery	250	60 g	artificial	50
bird pepper	OP	nursery	300	200 g	insects/self	500
hot pepper	OP	nursery	180	300 g	insects/self	500
hot pepper	hybrid	nursery	180	150 g	artificial	200
sweet pepper	hybrid	nursery	180	150 g	artificial	100
tomato	OP	nursery	300	150 g	self	150
tomato	hybrid	nursery	300	100 g	artificial	100
Leafy vegetables						
amaranth	OP	direct	3 000	20 kg	self/wind	800
sawah kangkong	clone	direct	cuttings	250 000	–	5 000 000
upland kangkong	OP	direct	25	20 kg	self	1 200
Roots, tubers, etc.						
asparagus	OP	nursery	25	4 kg	insects	400
carrot	OP	direct	860	4 kg	insects	400
maize cobs	OP	direct	7	20 kg	wind	2 000
sweet corn	hybrid	direct	7	15 kg	artificial	1 500
okra	OP	direct	20	6 kg	self/insects	800
yam bean	OP	direct	4	60 kg	self	800

1. OP = open pollinated landrace or local commercial variety.
2. Quantity of expensive hybrid seed reduced.
3. Yield very variable depending on variety, climate, soil, etc.

from improving the physical properties, this manure will amend the soil with considerable amounts of nutrients. For instance, 10 t of cow dung (LEHRI, West Java) contains 260 kg N, 45 kg P (corresponding to 100 kg P_2O_5) and 130 kg K (corresponding to 160 kg K_2O). These minerals are partly fixed in the organic material and are therefore released gradually. Thus, in the shallot example mentioned above, 10 t of cow dung might cover the entire uptake of these macro-nutrients. Unfortunately, in shallot production areas (Brebes-Tegal), insufficient farm manure is available and all nutrients are applied as mineral fertilizer.

The plant needs different quantities of nutrients during its lifetime. In order to reduce losses by leaching, especially in the rainy season, it is good practice to supply the N and K fertilizer, or at least the nitrogen, in split applications. The phosphate should preferably be given during ploughing or tillage, together with the organic manure, because it is not leached.

Many vegetable growers use foliar sprays of mineral fertilizers, often mixed with pesticides in the same sprayer. The quantity of macro-nutrients which

Table 6. Valuation of analytical data on chemical characteristics of the soil. Source: Soil Research Institute, Bogor, Indonesia.

Soil characters	Value				
	very low	low	average	high	very high
% C	< 1.00	1.00 – 2.00	2.01 – 3.00	3.01 – 5.00	> 5.00
% N	< 0.10	0.10 – 0.20	0.21 – 0.50	0.51 – 0.75	> 0.75
P_2O_5-HCl 25%, mg per 100 g	< 10	10 – 20	21 –40	41 –60	> 60
P_2O_5-Bray, mg/kg	< 10	10 – 15	16 –25	26 –35	> 35
P_2O_5-Olsen, mg/kg	< 10	10 – 25	26 –45	46 –60	> 60
K_2O-HCl 25%, mg per 100 g	< 10	10 – 20	21 –40	41 –60	> 60
CEC, me per 100 g	< 5	5 – 16	17 –24	25 –40	> 40
cations, me per100 g					
K	< 0.1	0.1 – 0.2	0.3 – 1.5	0.6 – 1.0	> 1.0
Na	< 0.1	0.1 – 0.3	0.4 – 0.7	0.8 – 1.0	> 1.0
Mg	< 0.4	0.4 – 1.0	1.1 – 2.0	2.1 – 8.0	> 8.0
Ca	< 2	2 – 5	6 –10	11 –20	> 20
% base saturation	< 20	20 – 35	36 –50	51 –70	> 70
% Al saturation	< 10	10 – 20	21 –30	31 –60	> 60
EC, mmho/cm	< 1	1 – 2	2 – 3	4 – 5	> 4
pH-H_2O	< 4.0	4.0 – 5.5	5.5 – 7.5	7.5 – 8.0	> 8.0
pH-KCl	< 2.5	2.5 – 4.0	4.0 – 6.0	6.0 – 6.5	> 6.5

can be applied with this method is very limited. The most profitable is the application of urea: with a 5% solution and 500 l/ha, the rate is 25 kg/ha of urea or only 12 kg N. Many types of foliar sprays with N, P, K, Mg and micronutrients are on sale. Apart from being expensive, they are superfluous in normal growing conditions. The drawbacks of foliar application are the risk of scorching the plant, the possible interference with the action of pesticides, and the corrosion of the sprayer apparatus. But foliar application may be justified to cure an apparent deficiency of a micro-nutrient, e.g. borium or iron deficiency on alkaline soils.

In practice, many types of organic waste material and all types of manure including nightsoil are used for vegetable production. If the C/N ratio of the material is above 15, as in the case of rice straw and bran, an addition of N fertilizer (7 kg per t straw) is recommended to avoid N deficiency. The high soil temperature in the lowlands ensures organic material decays fast. Crops such as amaranth can be grown successfully on fresh or only partly decomposed town waste, although there is a risk that this waste will pollute the soil with plastics and heavy metals.

Another way of increasing the organic matter content in soil is to grow a cover crop which is ploughed in before planting the main vegetable crop. A leguminous plant (e.g. *Crotalaria*) which fixes nitrogen through *Rhizobium* bacteria is normally used for this green manure. Although highly recommended by researchers, green manure is infrequently used by vegetable growers, for eco-

Table 7. Uptake of macro-nutrients by vegetable crops. Source: IFA World Fertilizer Use Manual 1992 (adapted).

Crop	Yield level (t/ha)	Uptake of nutrients (kg/ha)				
		N	P_2O_5	K_2O	CaO	MgO
Leafy vegetables						
spinach (crop)	21	131	34	226	41	42
lettuce (crop)	18	68	21	130	20	8
cabbage (crop)	29	169	45	148	29	7
cabbage (heads)	29	121	32	106	21	5
Fruit vegetables						
eggplant (crop)	40	207	46	340	•	•
eggplant (fruits)	40	75	27	108	4	12
okra (crop)	20	200	73	156	38	45
okra (fruits)	20	79	32	89	29	15
tomato (crop)	24	177	46	319	129	43
pepper (crop)	21	70	16	92	67	18
cucumber (crop)	20	55	38	98	49	14
cucumber (fruits)	20	39	27	70	35	10
watermelon (crop)	15	78	22	140	137	35
watermelon (fruits)	15	56	16	100	98	25
French bean (crop)	13	129	21	68	50	17
sweet corn (crop)	20	208	60	228	42	25
Roots, tubers, etc.						
carrot (crop)	43	126	71	175	224	20
onion (crop)	41	102	41	112	29	17
radish (crop)	19	276	89	389	147	76

nomic reasons. Mulching of vegetables with straw, usually rice straw, is a very common practice among vegetable growers in South-East Asia. Apart from reducing the growth of weeds, it limits sun burning of the organic material, impedes soil erosion, and keeps the soil cool and moist. The straw mulch gradually decays and becomes available to the soil as organic manure.

1.5.4 Crop protection

Vegetables in general are succulent crops and attractive to pests and disease organisms. In the international terminology, the word 'pest' is interpreted in two senses. In the broad sense it means any organism that hampers the crop: weeds, insects, mites, snails and slugs, rodents, birds, nematodes, fungi, bacteria, viruses. The word 'pest' in Integrated Pest Management (IPM) fits in this concept. In the more usual terminology all animal causes of plant damage except nematodes are called 'pests', whereas the microorganisms including nematodes are grouped as 'diseases' and the noxious plants competing with the crop are referred to as 'weeds'.

Exact information on the economic level of crop losses is limited. It is difficult to assess the losses caused by a single pest or disease. Crop health is the complicated outcome of the attack by several organisms trying to proliferate on plants with a genetically determined constitution, which is strongly influenced by the ecology. Overall yield losses in the vegetable sector may amount to 25%, which is higher than for all other categories of crops. For the farmer, the costs incurred for the chemical control of pests and diseases are very high, often between 100 and 400 US$ per ha or 10–40% of the variable costs (material inputs and labour). Diseases and pests cause a downgrading of the market quality and consequently of the farm-gate prices, and reduce the export chances.

Crop protection has evolved along with the crops and the cropping systems. In home gardens, fences were constructed to protect the vegetables from larger animals. Other simple control measures were the manual removal of caterpillars or repelling the insects with wood ash (a kind of chemical control). With the production of vegetables for the market, pest control measures became more urgent, in order to achieve the highest possible yield of products undamaged by pests or diseases. A number of non-indigenous pests such as the diamond-back moth (*Plutella xylostella*) and club root (*Plasmodiophora*) on cruciferous vegetables have been introduced into South-East Asia with planting material or otherwise and have become extremely troublesome (Eveleens & Vermeulen, 1976).

Compared with temperate countries, little is known of diseases and pests of vegetables in the tropics. The diseases and pests of individual vegetable crops are mentioned in the species descriptions. This section is restricted to some general observations about their control.

Chemical control

Although very costly, the application of pesticides has become the most common and easiest way of pest control in vegetables. Although there is a growing awareness of the dangers of toxic substances, the use of these biocides is still increasing and has reached levels at which there are health risks to growers and consumers, and considerable damage to the environment. The preventive spraying of pesticides has become routine, especially on the commercial highland vegetables of foreign origin, which lack the internal defence mechanisms of indigenous vegetables.

Encouraged by a sometimes rather aggressive sales promotion by chemical companies and by ineffective governmental control on toxicity or residual effects and by the lack of know-how among farmers and extensionists, the use of pesticides often leads to the intoxication of the people handling the pesticides and to noxious effects for the health of the consumers. In many places in South-East Asia the environment, the land and the water for drinking or fishing, has become polluted.

Chemical control has a serious negative side-effect; it destroys predators, parasites or natural enemies of the pest. This disturbance of the natural balance leads to a further intensification of the chemical treatments. Many pests have developed resistance to pesticides, forcing the farmers to spray more frequently and with stronger concentrations. The control of the diamond-back moth on cabbage is a notorious example. Yet another negative effect which is rarely rec-

ognized by the farmer is that many pesticides are phytotoxic. Crop damage often occurs when pesticides are sprayed in higher concentrations than prescribed, especially during the dry season. The concentration of fungicides on the leaves of e.g. tomato and capsicum pepper is often so high that the stomata are blocked and photosynthesis is hampered.
Thus, chemical treatments should be applied only when the economic threshold for damage is surpassed, when no other control measures are effective and when precautions are taken for safe use.

Biological control

The use of natural enemies to control a pest, i.e. predators, parasites or diseases, is called biological control. Many predators of insect pests on vegetables have already been found in South-East Asia. The rearing and release of egg parasitoids of the genus *Trichogramma* and larval parasitoids of the genus *Diadegma* for the control of diamond-back moth (*Plutella xylostella*) on cabbage has already been tried out in the highlands of the Philippines and Malaysia, apparently with some success (Talekar, 1992). The spraying of a bio-insecticide produced by the bacteria *Bacillus thuringiensis*, often called BT, is a promising microbial control method. Several strains of BT are known. This microbial insecticide is sometimes used against caterpillars in vegetable crops. The disadvantages of BT are that it is rather costly and that the insect population gradually develops resistance.

Control with cultural practices

Depending on the type of pest, the crop and the environment, the damage caused by pests can be kept at a low level with the right cultural practices. Whether these cultural practices are economic depends strongly on the local conditions and the skill of the farmer. Several cultural practices are known to reduce pest incidence and damage. 'Crop rotation' is effective in the control of soilborne diseases and sometimes also against insect pests. With the right 'time of planting', also called 'timing or planning of crop production', certain important pests may be avoided; insects are often more abundant in the dry season, whereas fungal diseases are worse during the rainy season. 'Mixed intercropping' sometimes reduces the pest incidence, e.g. tomato plants and garlic are known to repel insect pests of cabbage or carrot. 'Disinfection by heating' of nursery soil against pathogens like *Pythium* (damping-off) is sometimes practised, e.g. for raising tomato or capsicum pepper transplants. A 'balanced fertilization' with a reduction of the often too high dose of nitrogen makes the crop stronger and less attractive to pathogens. The 'soil structure and pH' are very important for crop health. Organic manure improves the soil structure and reduces bacterial wilt and nematodes. 'Liming' of acid soils reduces club root disease of crucifers. Good 'drainage' reduces bacterial wilt and fungus diseases of many crops. 'Mulching' with rice straw or plastic is a method of weed control and reduces soil erosion and bacterial wilt. Plastic mulch is reported to reduce thrips and aphid populations. In some areas, farmers raise nursery plants (cabbage, capsicum pepper, tomato) and even whole crops (cabbage) under fine-mesh insect-proof 'nylon netting'. Netting whole fields of Chinese kale (kailan) is used against diamond-back moth in Thailand. Good 'sanitation' is another helpful practice. This means the removal of crop residues and of infected plants or planting material (roguing). In shallot growing in Indonesia it is common practice to pick off all *Spodoptera* caterpillars and egg clusters by hand and to destroy them.

Control with resistant cultivars

The cheapest and most practical control method is to use resistant cultivars. Landraces generally possess high 'horizontal resistance', a genetically determined level of tolerance, which means the plants are attacked but do not suffer very much. This is in contrast to many resistances in modern cultivars, which are narrowly based on one or a few genes. These resistances are often broken in a short time, by the pathogen evolving and forming new strains or races. Plant breeders have developed hundreds of cultivars of the more important commercial vegetables with resistant genes against fungal or bacterial diseases, nematodes and viruses, but resistance to insects or mites is very rare. The existence of resistant cultivars is mentioned in the species treatments.

Integrated control

Integrated Pest Management (IPM) is a worldwide accepted control method for diseases and pests. It is a combination of non-chemical control measures (resistant cultivars, cultural practices, biological control) with a minimum use of indispensable pesticides based upon threshhold observations. It is mostly practised for insect pests and often concentrates on a single major pest such as diamond-back moth of cabbage.

If the overall health condition of the crop is taken as the major issue, a more holistic approach to integrated control is the Integrated Crop Management (ICM), which takes the coherence and relationship between human and environmental factors into consideration. ICM is defined as 'a system whereby all interacting crop production and pest control tactics aimed at maintaining and protecting plant health are harmonized in the appropriate sequence to achieve optimum crop yield and quality and maximum net profit, in addition to stability in the agro-ecosystem, benefiting society and mankind' (El-Zik & Frisbie, 1985).

1.6 Harvesting and post-harvest handling

First of all it is important to realize that pre-harvest choices such as cultivar and cultural practices, strongly influence the quality obtained at harvesting. Size, form, colour, firmness, taste and other internal and external product qualities are genetically determined. During cultivation, all measures which assure good health of the crop also have an impact on the post-harvest quality. The plant density influences the product size and form. A common mistake is to apply too much nitrogen fertilizer, which makes the harvested product more watery, weaker and more susceptible to damage and rotting.

Most vegetables are very perishable products. The losses of product and deterioration of quality caused by inappropriate harvesting and post-harvest handling are considerable. Losses of one-third of the harvested product are not exceptional. Harvested vegetables are still living parts of plants, which remain very susceptible to damage until ultimate consumption. Vegetables have a high water content (70–95%) and the leafy types in particular will wilt easily because of continuing respiration after the harvest. Some recommendations regarding the correct handling of harvested vegetables to minimize losses are given below.

Harvesting

Two types of harvesting methods may be distinguished. Once-over harvesting is the harvest of all the useful parts or of all plants at once. This is practised e.g. on carrot, radish, cabbage, onion, garlic. More common is the repeated harvesting of the plant parts desired in several picking rounds, e.g. for capsicum pepper, cucumber, tomato, yard-long bean, asparagus. In many cases the grower himself can choose which type of harvest will be applied. Many leafy vegetables (amaranth, kangkong) can be once-over harvested by uprooting or cutting the whole plants, or they can be harvested repeatedly by successive cuts. In the latter case, the cultural practices will be different; in the example of amaranth, the amount of nitrogen fertilizer, the height and frequency of cutting, the plant spacing and their interactions will strongly influence the ultimate yield and quality, in particular through their effect on flowering (Grubben, 1976).
The maturity stage of the product wanted is greatly influenced by the time and frequency of harvesting. For example in tomato, the farmer has to consider the maturity stage requested by the dealer. If harvested immature green, the tomatoes will not taste good. Mature fruits have the best taste but will not tolerate several days of transport and storage. The farmer will try to compromise by harvesting at the mature-green stage to let the fruits ripen in transit or storage before marketing. To deliver high quality products, the farmer must have a good knowledge of harvest indices: size, colour, firmness.

Grading

Post-harvest handling has the objective of bringing the harvested product to the consumer with a minimum of quality deterioration. A first step is a sorting into various quality classes or gradings. The principle is a two-way sorting, i.e. by appearance and size. An example is presented in Table 8, giving the prescriptions for the eight quality classes used in the trade of shallot in Indonesia (Schoneveld, 1992).

Packing and transport

Proper packaging is aimed at avoiding mechanical damage by pressure and at avoiding warming-up from respiration by inadequate ventilation. Excessive ventilation is also undesirable, as it results in wilting and weight loss. The packing materials used for vegetables are very diverse: net bags, bamboo baskets, wooden or plastic crates, cardboard boxes and plastic bags, and also loose on the truck. The choice is purely economic: cheap packing materials generally lead to more deterioration of quality and a lower price. A suitable packing unit is 20 kg. Bags with dried products such as garlic and shallot may contain 40 kg. Packing units are often made too large and too heavy (sometimes 100 kg baskets or bags) for easy handling. They lack sufficient ventilation, and heating of the product can easily cause serious rotting. The main cause of post-harvest losses during storage and transport, however, is the pressure from the product loaded on top. Figure 2 illustrates how the damage by pressure can be reduced by the installation of partition floors or by using self-supporting crates (Schoneveld, 1992). Clearly, the pressure on the lowest product is least for solution G (small self-supporting crates).

Storage

Vegetables can be stored in a cool, dark, well-ventilated place. Leaf vegetables must be wetted occasionally, to avoid drying out. The best keeping is in a cool room, but this method is too expensive for the individual farmer and for most dealers. Some vegetables keep well at low temperatures of 1–2°C (*Allium* crops, cabbage, radish), but most other products will suffer damage at those temperatures. For example capsicum pepper stores better at 5–7°C, cucumber at 10–12°C. Onion, shallot and garlic also store well in the lowlands in well-ventilated sheds; a temperature above 27°C impedes early sprouting. Leafy vegetables may be packed with shredded ice to keep them fresh during long-distance transport. Fresh exports require sophisticated post-harvest facilities and transport infrastructures to deliver fast and timely, as well as top-quality produce.

1.7 Utilization and processing

The utilization of vegetable products is changing constantly. The development of new types of food is in general leading to higher levels of consumption. In South-East Asia it is customary to consume vegetables as fresh as possible. Many housewives buy fresh vegetables once or even twice a day. Yet processed vegetables are becoming more popular for reasons of convenience.

Processing techniques are of the utmost importance in the vegetable sector, because of the perishable nature of the product. Apart from adding value, processing enables the fresh market to be relieved when prices are low due to a glut in production, and also avoids wasting produce which is not marketable because of its small size or less attractive appearance.

Table 8. Quality classes for shallot in Indonesia. Source: Schoneveld, 1992.

A(export market)	B(domestic)	C(domestic)	D(domestic)
dried bright round no diseases	dried/fresh bright deep red no diseases	dried/fresh discoloured malformed diseases	dried/fresh discoloured damaged low keepability
1 (> 3 cm) 2 (2.5–3 cm) 3 (1.5–2.5 cm)	4 (> 2.5 cm) 5 (1.5–2.5 cm) 6 (< 1.5 cm)	7 (any size)	8 (any size)

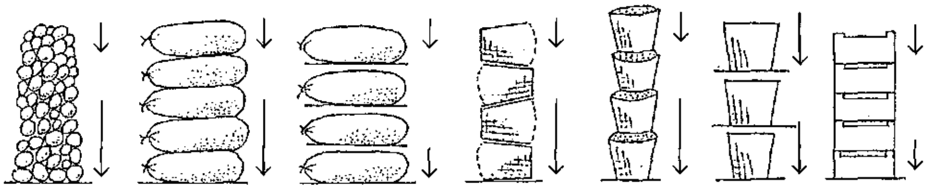


Figure 2. Methods of loading during storage and transport. Source: Schoneveld, 1992.

Vegetable products are mainly processed by drying or dehydration, pickling, canning, and freezing. Drying or dehydration is one of the oldest preserving methods; the principle consists of reducing the moisture content below that at which microorganisms grow and reproduce. It is usually accomplished through heat (e.g. sunshine) and ventilation; for aromatic vegetables dehumidifiers are more suitable, in order not to lose the volatile oils. The drying of green leaves (*Corchorus olitorius* L., *Sesamum radiatum* Thonn. ex Hornem.) and fruits (okra, capsicum pepper, local eggplant, pumpkin) and their preservation as powder is common practice in Africa. Some of the food value is lost in the process, but drying merits more investigation as it is a simple technique that can be widely used throughout the tropics. Pickling is preservation in brine or vinegar, with or without bacterial fermentation. There are many traditional methods for preparing salted and pickled vegetables in South-East Asia.

Mixed vegetable and fruit juices are becoming increasingly popular.

Canning fruits and vegetables is becoming an established practice in South-East Asia, but preservation by freezing is still in its infancy.

1.8 Genetic resources and breeding

Knowledge of the use of wild plants is disappearing rapidly. It is only natural that the importance of the wild flora as a direct food source is decreasing, but it is inadmissible for genetic resources to be destroyed before the true value has been assessed objectively.

The development of modern horticulture has led to a huge reduction in the number of vegetable species. It has also resulted in a narrowing of the genetic base of the remaining species, because a large number of local, unselected cultivars have been replaced by fewer highly selected planting materials. Plant breeders have to rely on genetic resources, which can be found in the primary and secondary centres of diversity or in artificial germplasm collections.

The establishment of the International Board of Plant Genetic Resources (IBPGR) in 1974 greatly increased the awareness of the importance of crop germplasm and led to the establishment of numerous collections of species endangered by genetic erosion. Based on a study of tropical vegetables and their genetic resources (Grubben, 1977), in 1979 IBPGR prioritized eight vegetable genera or groups for immediate action, i.e. *Abelmoschus*, *Allium*, *Amaranthus*, *Capsicum*, Cruciferae, Cucurbitaceae, *Lycopersicon*, and *Solanum melongena* (van Sloten, 1980).

Information on existing collections was compiled in a Directory of Germplasm Collections. 4. Vegetables (Bettencourt & Konopka, 1990).

Selection and breeding have an important role to play in the improvement of vegetable crops. Named, well-defined cultivars have so far only been developed in an estimated 60 species out of the 225 primary use vegetables described in this book, and a large part of these originate from outside South-East Asia. The development and release of cultivars in most South-East Asian countries is still the task of public research and extension agencies, although the involvement of the private sector is increasing.

The establishment of the Asian Vegetable Research and Development Center (AVRDC) in 1971 has given a strong impetus to the development of advanced breeding programmes in South-East Asia on a number of vegetable crops such as tomato and Chinese cabbage. Its training programmes have also strengthened the national programmes in other crops.

There are two aspects to the breeding philosophy in South-East Asia. The first, easily overlooked or neglected, is to select or breed for low-input farms where standard cultivars are required that respond to low levels of fertilizer, are adapted to a wide range of environmental conditions, and are tolerant of common diseases and pests. This implies collecting, evaluating and maintaining the germplasm of a wide range of crops, doing research and gathering information on crop characteristics, and finally, selecting suitable cultivars by conventional selection techniques. These tasks are best performed by government research and extension agencies with an overall responsibility for the sector; they should supply local private seed companies with breeding material or selections to be multiplied into commercial, good quality seed for the farmer.

The other aspect is the development of high-yielding cultivars for commercial farms, which give maximum response to optimal input. It is at this level that good commercial opportunities exist for the private sector.

1.9 Prospects

This volume is proof of the great wealth and diversity of vegetables in South-East Asia. The development of the horticultural sector is first and foremost a matter of allocation of resources. However, new revolutionary solutions have to be found to achieve sustainable production systems. As the train of horticultural development gathers speed, efforts should be made not to repeat the mistakes of the industrialized world, i.e. environment-unfriendly production methods and a considerable loss of genetic diversity.

1.9.1 Research

Notwithstanding the significance of the vegetable sector in the agricultural economy, the diffuse distribution and species diversity have made it hard to develop a compelling rationale for allocating appropriate resources for vegetable crop research.

Most countries in South-East Asia have facilities for vegetable research (LEHRI, Indonesia; MARDI, Malaysia; IPB, the Philippines; Institute of Horticulture, Thailand; Institute of Agricultural Science, Vietnam), but in general the allocation of resources does not reflect the economic (and nutritional) importance of the sector. In setting priorities within the sector, the 'exotic' highland species (cabbage, potato, etc.) have received much attention, and the indigenous vegetables have scored low, but they have not yet lost the battle. Numerous new initiatives have recently been taken to promote lowland vegetable research, e.g. at LEHRI, Indonesia.

At the international level, the Asian Vegetable Research and Development Center (AVRDC) has done pioneering research on Chinese cabbage and tomato. In its strategic plan for the 1990s (AVDRC, 1991), it has clearly opted to give first priority to the lowland humid and subhumid tropics, to concentrate on small-scale commercial production, and to expand its commodity coverage to capsicum peppers, eggplant, and the important *Allium* crops (onion, shallot, garlic). It plans to put more emphasis on a decentralized organizational set-up with regional research networks, and by so doing is pursuing the same line as the Consultative Group on International Agricultural Research (CGIAR), which is studying new ways of promoting tropical vegetable research, possibly through a new coordinating body (such as IBPGR) with the task of stimulating the development of national research systems (Winrock International, 1986).

1.9.2 Marketing infrastructure

National policies tend to emphasize the development of exports rather than domestic consumption, but a well-supported domestic market is the best possible basis for export. The rapid expansion of the supermarket system of selling fresh vegetables, with its insistence on quality, will in time stimulate the adoption of improved marketing methods. The prospects for fresh exports to large urban centres (Singapore) and nearby industrialized countries (Taiwan, Japan) are certainly good, but more is to be expected from exports of preserved and processed products. However, this export sector should develop as a by-product of processing industries aimed at the large domestic markets. Vegetables in general have a positive income elasticity and with increasing economic prosperity, the production of market vegetables will increase.

1.9.3 Seed industry

The rapid expansion of commercial vegetable production creates a market for high-quality seed. Growers are changing their attitude from considering vegetable seeds as a cheap internal input to the conviction that it pays to start a crop with healthy market seed of an improved cultivar purchased from a professional seed producer.

In some cases it may be justified that the public sector (National Agricultural Research Systems) produces market seed itself. However, international experience has proven that farmers are generally better off when the public sector takes care of the more fundamental part of research in support of the private seed sector. The public sector should be responsible for independent testing of the value of new and existing cultivars, the release policy for new cultivars, and the control of seed quality.

The size of the national seed market determines whether the seed can be produced in a country. A sound government policy should stimulate breeding activities and seed production in the vegetable production areas of the country in the interest of farmers and consumers. Apart from a few exceptions (e.g. white cabbage), it is technically and economically feasible to produce all vegetable seed in the South-East Asian region.

G.J.H. Grubben, J.S. Siemonsma & Kasem Piluek

2 Alphabetical treatment of species

Abelmoschus esculentus (L.) Moench

Methodus: 617 (1794).
MALVACEAE
$2n = 130$ (66–144)

Synonyms *Hibiscus esculentus* L. (1753).

Vernacular names Okra, lady's finger (En). Gombo (Fr). Indonesia: okra, kopi arab. Malaysia: kacang bendi, sayur bendi, kacang lender. Philippines: okra, saluyot a bunga (Ilocano), haluyot (Ifugao). Burma: you-padi. Cambodia: pôôt barang. Laos: khüa ngwàng. Thailand: krachiap-khieo (central), krachiap-mon (central), bakhua-mun (northern). Vietnam: d[aaj]u b[aws]p, b[uj] b[aws]p, m[uw][ows]p t[aa]y.

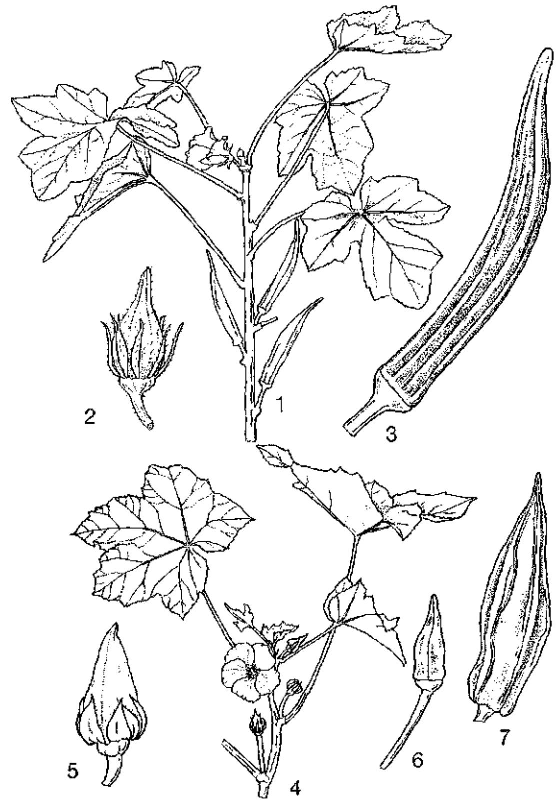
Origin and geographic distribution The genus *Abelmoschus* Medikus originated in South-East Asia. *A. esculentus,* however, is a cultigen of uncertain origin. It is now widely cultivated in tropical and subtropical regions, but is particularly popular in India, West Africa and Brazil. Okra is common in the Philippines, Malaysia, Thailand and Vietnam, but of little importance in Indonesia and Papua New Guinea.

Uses Okra is mainly grown for its young immature fruits, which are consumed as a vegetable, raw, cooked or fried. It is a common ingredient of soups and sauces. The fruits can be conserved by drying or pickling. The leaves are sometimes used as spinach or cattle feed, the fibres from the stem for cord, the plant mucilages for medical and industrial purposes, and the seeds as a substitute for coffee. Okra seeds contain a considerable amount of good quality oil and protein.

Production and international trade World okra production is estimated to be 5–6 million t/year, which is about 1.5% of total world production of vegetables. No production statistics are available from South-East Asian countries. Some fresh or frozen okra is exported from Thailand and the Philippines to Japan, and okra in brine is a potential export item to the Middle East.

Properties Per 100 g edible portion, the fruits contain: water 90 g, protein 2 g, fibre 1 g and carbohydrates 7 g. The energy value is about 145 kJ/100 g. Okra is a good source of vitamins and minerals. Compared with other fleshy fruits (tomato, eggplant), it is particularly rich in Ca (70–90 mg per 100 g).
The 1000-seed weight varies from 30–80 g.

Description Stout, erect, annual herb, up to 4 m tall. Leaves spirally arranged, leaf-blade up to 50 cm in diameter, more or less deeply 3-, 5- or 7-lobed; petiole up to 50 cm long, stipules filiform,



Abelmoschus esculentus (L.) Moench – 1, flowering and fruiting shoot; 2, flower bud; 3, young fruit. Abelmoschus caillei (A. Chev.) Stevels – 4, flowering and fruiting shoot; 5, flower bud; 6, young fruit; 7, mature fruit.

up to 20 mm long, often split to the base. Flowers solitary in the leaf axils or in pseudoracemes by reduction of the upper leaves, yellow, self-fertile; pedicel up to 3 cm long in flower, up to 7 cm long in fruit; epicalyx of 7–15 free, linear segments, 5–25 mm × 0.5–3 mm; calyx spathaceous, 2–6 cm long, splitting on one side during the expansion of the corolla, adnate to and falling with the corolla; corolla with 5 obovate petals, each about 3–7 cm long and wide, yellow with a dark purple centre. Fruit a cylindrical to pyramidal capsule, 5–35 cm long, 1–5 cm in diameter, completely, partially or not loculicidal, green, greenish-purple or completely purple when young, brownish when mature. Seeds numerous, globose, 3–6 mm in diameter, blackish. Germination is epigeal.

Growth and development Okra usually flowers within 40–90 days after sowing; its cropping period rarely exceeds 6 months. Self-pollination and flower opening take place in the early morning. Partial cross-pollination by insects may take place. For vegetable use, the fruits are picked about one week after anthesis. It takes about one month from anthesis to mature fruit. In the seed crop, vegetative growth stops soon after anthesis, all assimilates being partitioned to the reproductive plant parts. In the vegetable crop, the picking of young fruits permits sustained vegetative growth, prolonging the harvest.

Other botanical information *A. esculentus* ($2n = 130$) is probably an amphidiploid (allotetraploid), derived from *A. tuberculatus* Pal & Singh ($2n = 58$), a wild species from India, and a still unknown species with $2n = 72$ chromosomes.

Another edible okra species occurs in the humid parts of West and central Africa. Described originally as a botanical variety (*Hibiscus manihot* L. var. *caillei* A. Chev.), it has recently been recognized as a distinct species (*A. caillei* (A. Chev.) Stevels). There are no apparent differences in use between the ordinary (*A. esculentus*) and West African okra (*A. caillei*), which is why they are often lumped together. Morphologically the West African okra differs in several respects, but its epicalyx offers the best discriminating characteristics with 5–10 free, ovate segments, 10–35 mm × 4–13 mm. The plant is more robust than *A. esculentus*, and crop duration may exceed 12 months. It has very many chromosomes ($2n$ = approximately 192 (184–200)) and it might be an allohexaploid, *A. esculentus* being one of the parents.

There are many cultivars of okra. Some of the better known are 'Clemson Spineless' (United States) and 'Pusa Sawani' (India).

Ecology *A. esculentus* needs temperatures above 20°C for normal growth and development. Germination percentage and speed of emergence are optimal at 30–35°C. Flower initiation and flowering are delayed at higher temperatures (positive correlation between temperature and number of vegetative nodes). *A. esculentus* is a short-day plant, but its wide geographical distribution (up to latitudes of 35–40°) indicates that cultivars differ markedly in sensitivity. Flower initiation and flowering are hardly affected by daylength in popular subtropical cultivars such as 'Clemson Spineless' and 'Pusa Sawani'. Most tropical cultivars show quantitative short-day responses, but qualitative responses also occur. The shortest reported critical daylength is 12 hours 30 minutes.

The West African okra is considerably more sensitive to photoperiod. This partly explains its limited geographical distribution (up to latitudes of 10–15°) and longer life-cycle. The shortest reported critical daylength is 12 hours 15 minutes.

Okra does well on fertile light or heavy soils if well drained.

Propagation and planting Propagation is by seed. Most farmers harvest seed from their own local cultivar or rather heterogeneous landrace. The easiest way to keep the seed is to leave it in the pods until it is used. To soften the hard seed coat, the seed is often soaked in water. The seed is usually dibbled into individual hills directly in the field. Optimum plant densities for *A. esculentus* are in the range of 50 000–150 000 plants/ha. The robust West African okra should be planted at 20 000–50 000 plants/ha. A common planting pattern is a spacing of 60–80 cm between the rows, with one seed per hill every 10 cm or two seeds per hill every 15–20 cm. Rows in east-west direction will best capture the sunlight. Emergence is within one week. When the plants are about 10 cm tall, they could be thinned to one plant per hill or one plant every 20 cm. The seed requirement is 3–5 kg/ha.

Some farmers practise ratoon cropping. A ratoon crop flowers in 35 days after cutting and may give a higher yield than the seed-propagated mother crop. However, the quality of the fruits is always inferior in the ratoon crop (high percentage of bent fruits).

Husbandry Commercial growers usually cultivate okra in sole cropping. For home consumption, a few plants are grown in home gardens or in fields of other food crops. The uptake of minerals is rather high. Indicative figures for total nutrient uptake per ha (crop with fruit yield of about 10 t/ha) are 100 kg N, 10 kg P, 60 kg K, 80 kg Ca and 40 kg Mg. The fertilizer recommendation in Indonesia is 10 t/ha of organic manure applied to the planting holes together with TSP 150 kg and KCl 150 kg. Urea 150 kg/ha or ammonium sulphate 300 kg/ha can be given in three split applications: at sowing, after 3 weeks and again at 6 weeks after sowing. If the vegetative development at the age of three weeks is too luxurious, no N fertilizer should be applied anymore, otherwise the harvest will be delayed and the crop will become attractive to insects. Furrow irrigation must be given when needed. A full-grown crop consumes about 8 mm water per day. Weeding is only needed during the first month and can be combined with earthing-up.

Diseases and pests The most serious fungal diseases are *Cercospora* blight (*C. abelmoschi* and

C. malayensis), powdery mildew (*Erysiphe cichoracearum*) and fruit rot (*Choanephora cucurbitarum*). They are controlled by spraying with fungicides. Some other diseases are *Fusarium* wilt, pod spot (*Ascochyta abelmoschii*) and anthracnose (*Colletotrichum hibisci*). Yellow-vein mosaic virus (YVMV) is a major cause of crop failure in Asia, whitefly (*Bemisia tabaci*) being the vector. Viruses must be controlled through the use of healthy seed or the chemical control of the vectors (aphids, whitefly).

Important pests of okra are fruit and stem-borers (*Earias* spp., *Heliothis armigera*), jassids (*Empoasca* spp.), stink bugs (*Nezara viridula, Dysdercus* spp.) and root knot nematodes. Chemical control of insects is hazardous because harvesting is so frequent. Damage by nematodes is avoided by respecting crop rotation and by high doses of organic manure.

The West African okra is much more tolerant of diseases and pests than the ordinary okra.

Harvesting Early-maturing cultivars give the first harvest at 7 weeks after sowing. A developing fruit should be harvested when 7–8 days old. Earlier picking depresses yields because of suboptimal fruit weight. Delayed picking depresses marketable yields because over-aged fruits become fibrous. Therefore, okra fields are harvested at intervals of 2–3 days. For seed production, the whole crop can be harvested at once. Intensive contact with the slightly hairy fruits and plants may lead to skin irritation.

Yield A yield of 10 t/ha can be considered a good harvest, but yields over 40 t/ha can be realized under optimal conditions. Usually yields are low (2–4 t/ha), because of the extensive cultivation.

Handling after harvest Fresh okra can quite easily be transported in bulk and kept for several days without much loss of quality. Dried okra is an important product in West Africa. Some countries have a small canning and freezing industry.

Genetic resources Germplasm base collections are maintained by USDA (Fort Collins, United States), NIHORT (Ibadan, Nigeria), ORSTOM (Montpellier, France), IDESSA (Bouaké, Ivory Coast), NBPGR (New Delhi, India) and IPB (Los Baños, the Philippines). Local okra landraces are in great risk of genetic erosion because growers tend to switch to commercial cultivars.

Through the IBPGR germplasm network, the West African okra has already been introduced in several American and Asian countries.

Breeding Work has been oriented towards intensive cultivation with high production in a short period (early maturity, high density planting) and wide adaptation (photoperiod insensitivity, resistance to pests and diseases). Several attractive American (e.g. 'Clemson Spineless') and Indian cultivars (e.g. 'Pusa Sawani') have found their way to commercial growers throughout the tropics and subtropics. Resistance to many diseases and pests has been identified in available okra germplasm, but not yet so to YVMV, a major problem in Asia.

Little attention has been given to the needs of the traditional sector (cultivation for home consumption), where hardy, robust, long-lived types such as the West African okra are required. The characteristics of both okra species open up new opportunities for recombination. They cross readily in both directions and give vigorous hybrids; these, however, show strongly reduced fertility.

Prospects Okra will remain a welcome, productive tropical and subtropical fresh vegetable. The discovery of a second edible species in West Africa calls for a detailed study of its potential in other continents. Okra improvement will also greatly benefit from a better understanding of the phylogeny and species relations within the genus *Abelmoschus*.

Literature |1| Bautista, O.D.K. & Cadiz, T.G., 1967. Okra. In: Knott, J.E. & Deanon Jr, J.R. (Editors): Vegetable production in South-East Asia. University of the Philippines Press, Los Baños, the Philippines. pp. 263–268. |2| Charrier, A., 1984. Genetic resources of Abelmoschus (okra). International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 61 pp. |3| IBPGR, 1991. Report of an international workshop on okra genetic resources, held at the National Bureau for Plant Genetic Resources (NBPGR), New Delhi, India, 8–12 October 1990. International Crop Network Series. 5. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 133 pp. |4| Markose, B.L. & Peter, K.V., 1990. Okra. Review of research on vegetables and tuber crops. Technical Bulletin 16. Kerala Agricultural University Press, Mannuthy, Kerala, India. 109 pp. |5| Martin, F.W. & Ruberté, R., 1978. Vegetables for the hot humid tropics. Part 2. Okra, Abelmoschus esculentus. Mayaguez Institute of Tropical Agriculture, Puerto Rico, United States. 22 pp. |6| Siemonsma, J.S., 1982. West African okra – morphological and cytogenetical indications for the existence of a natural amphidiploid of Abelmoschus esculentus (L.) Moench and A. manihot (L.) Medikus. Euphytica 31: 241–252. |7| Siemonsma, J.S., 1982. La culture du gombo (Abelmoschus spp.), légume-fruit tropical (avec référence spéciale à la Côte d'Ivoire) [Cultivation of the tropical fruit-vegetable okra (Abelmoschus spp.), with special reference to Ivory Coast]. Thesis, Wageningen Agricultural University, the Netherlands. 297 pp.

J.S. Siemonsma

Abelmoschus manihot (L.) Medikus

Malvenfam.: 46 (1787).

MALVACEAE

$2n = 60–68$

Synonyms *Hibiscus manihot* L. (1753), *Abelmoschus manihot* (L.) Medikus ssp. *manihot*.

Vernacular names Aibika (Pidgin), sunset hibiscus (En). Indonesia: gedi (Minahasa), degi (Ternate). Papua New Guinea: aibika. Philippines: lagikuway (Tagalog), barakue (Batanes), glikway (Subanon). Thailand: po-fai (northern).

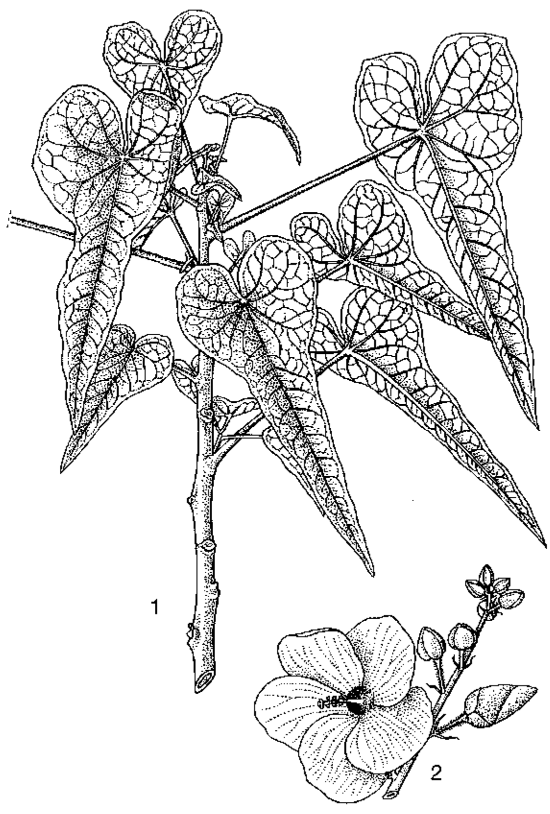
Origin and geographic distribution The genus *Abelmoschus* Medikus has its origin in continental South-East Asia. Its species are distributed mainly in South Asia, East Asia, South-East Asia and northern Australia. *A. manihot* is a cultigen with a wide distribution. It is a popular traditional vegetable in Melanesia, but has also been introduced into other continents, either as a vegetable or as an ornamental (sunset 'hibiscus'). In South-East Asia it is cultivated particularly in the eastern parts of Indonesia and in Papua New Guinea.

Uses Aibika is grown for its young leaves and stem tips which are used as a cooked green vegetable. Leaves become slimy upon cooking. Even in areas where the vegetable use is not popular (e.g. West Java), *A. manihot* is commonly planted in home gardens, either as an ornamental or for traditional medicinal use. It is often described by Javanese villagers as 'cassava without tubers' because its aerial parts resemble cassava.

Production and international trade Aibika is the most important leafy vegetable in Papua New Guinea and Irian Jaya. In other parts of South-East Asia it is only of local or regional importance. It is grown in compounds for home consumption and constitutes a popular market vegetable. No production statistics are available.

Properties Per 100 g edible portion, aibika leaves and stem tips contain: water 90 g, protein 4.1 g, fat 0.4 g, carbohydrates 4 g, fibre 1 g. The energy value is 150 kJ/100 g. It is a rich source of vitamins and minerals: vitamin A 900 IU, vitamin C 118 mg, Ca 580 mg, Fe 3 mg. Aibika has been recommended by the World Health Organization as a good baby-food, because young leaves are almost fibreless and are easy to mash after boiling.

Description Perennial shrub, 1–3(–7) m tall. Root system usually adventitious and fairly shallow with most of the roots in the top 30–40 cm of the soil. Stem erect, woody, branching, glabrous or pubescent (without prickly hairs unlike related wild forms). Leaves simple, alternate, extremely variable in shape, size, colour and pigmentation (or marking); petiole 3–25 cm long, stipules filiform or lanceolate, 5–12 mm long; leaf-blade linear, lanceolate, cordate or deeply lobed or parted with 3–7 segments, colour varying from light to dark green through red to purple. Flowers large, bell-shaped, 7–15 cm in diameter, axillary, solitary or in racemes by the reduction or abortion of the upper leaves; pedicel 1–5(–7) cm long; epicalyx segments 4–6(–8), free, ovate to oblong, 1–3 cm × 0.5–1 cm; calyx spathaceous, 2–3 cm long, splitting on one side during the expansion of the corolla, adnate to and falling with the corolla; corolla consisting of 5 large, obovate to orbicular petals,



Abelmoschus manihot (L.) Medikus – 1, leafy shoot; 2, flowering shoot (pseudoraceme).

3–8 cm in diameter, pale yellow with a dark brown or reddish central spot; ovary superior, 5-celled; style surrounded by the staminal column from which it emerges and divides into 5 lobes, each ending in a flattened, disk-shaped, dark brown stigma; staminal column up to 3 cm long, white, bearing numerous filaments and anthers. Fruit an oblong-ovoid capsule, 3.5–6 cm × 2–2.5 cm, hairy, usually 5-angled and splitting into 5 segments. Seeds numerous, spherical to reniform, 2–4 mm in diameter, black.

Growth and development Aibika propagated from cuttings grows rather slowly during the first 2–3 months and does not cover the ground adequately. After harvesting has started, the regular removal of the growing tips encourages branching and compact bushy growth, and delays flowering.

Other botanical information *A. manihot* is a polymorphic species and its delimitation has been subject to much debate. In a wide sense, it comprises 2 subspecies: ssp. *manihot* ($2n$ = 60–68, stems without prickly hairs, cultigen) and ssp. *tetraphyllus* (Roxb. ex Hornem.) Borss. ($2n$ = 130–138, stems with prickly hairs, wild). The present-day tendency followed here is to use *A. manihot* in a narrow sense (restricted to ssp. *manihot*) and to recognize ssp. *tetraphyllus* as a distinct species: *A. tetraphyllus* (Roxb. ex Hornem.) R. Graham.

In the literature the great variability of *A. manihot* has been described in many botanical forms, differing mainly in leaf shape, size and colour. Distinction of cultivar groups would be more appropriate, but has not yet been done formally.

Ecology Aibika grows over a wide range of climates but in the tropics mainly occurs from the lowlands to 1200 m altitude. However, at high elevations, growth is slower. It requires well-distributed rainfall of at least 1200 mm/year for good production. *A. manihot* is sensitive to waterlogging and prefers well-drained loams with a pH of 5.5–7, but grows on a wide range of soils. Little is known about the eco-physiology of *A. manihot*, but there are indications that it behaves as a qualitative short-day plant. In Port Moresby (9°S), aibika flowers between July and November.

Propagation and planting Although aibika can be propagated from seed, it is easier to use stem cuttings. Traditionally, in Papua New Guinea and Irian Jaya, cuttings of 40–50 cm length are used. If planting material is scarce, they may be shorter but should have at least 3–4 nodes. Cuttings are planted directly in the field, buried about half their length, at a spacing of 25–100 cm in rows 1 m apart (10000–40000 plants/ha), preferably at the start of the main rains. Cuttings which have not sprouted in 3 weeks should be replaced. A fairly rough seed-bed, obtained by hoeing or disk ploughing and harrowing is adequate since quite large cuttings are used. Perennial weeds should be removed before planting. Manure at 20–30 t/ha should be incorporated before planting.

Husbandry Aibika should be clean-weeded; this is best achieved with a thick layer of grass mulch which also controls soil erosion. Although the fertilizer and manure requirements of aibika have not been worked out, observations in Papua New Guinea have shown that it responds to fertilizers by producing bigger leaves and this is likely to lead to higher yields. When aibika starts being harvested, top dressing with 10 kg/ha of nitrogen at monthly intervals (120 kg/ha per year) will maintain active vegetative growth and yield. Aibika can be grown at any stage of the rotation, and can be intercropped with a wide range of annual crops.

Diseases and pests No serious diseases have been reported. Collar rot (*Phytophthora nicotianae*), leaf-spot (*Cunninghamella* spp.), powdery mildew and green mottle (probably a virus) have been reported from Papua New Guinea. Control measures are not usually economic. Like all malvaceous plants, aibika is very attractive for insects. Important pests include leaf rollers (*Sylepta derogata*), semi-loopers (*Anomis flava*), flea beetles (*Nisotra* sp.), jassids (*Amrasca* sp.), white scale (*Pseudaulacaspis pentagona*), red/black scale (*Parasaisettia nigra*), and various other sucking bugs, leaf-eating caterpillars, beetles and grass hoppers.

Harvesting Tips of shoots, consisting of the growing point and a few young leaves are harvested. New shoots develop from axillary buds and provide another harvest in about 4 weeks. Harvesting starts about 80–90 days after planting and the bush remains productive for at least a year.

Yield Annual yields of 5–15 t/ha can easily be obtained. When well watered and manured, yields of 40–60 t/ha per year are possible.

Handling after harvest Aibika is marketed as fresh leaves on the day of harvest. No further processing or preservation is currently practised.

Genetic resources New Guinea is an important centre of diversity for *A. manihot*, but numerous types have also been described from other parts of the region, in particular the eastern parts of Indonesia. Collections have only systematically been made in Papua New Guinea, and they are maintained as living plant collection by the Laloki Research Station, Konedobu.

Breeding Little or no breeding work has been done on aibika anywhere. Work has been limited to cultivar trials and compatibility studies. *A. manihot* is self-fertile but from studies of seedling populations it is obvious that there is a high degree of outcrossing.

Prospects Aibika makes a substantial contribution to the diet of Melanesians, and could very well do so in other parts of South-East Asia. Very little is known about *A. manihot* in general, and the Melanesian plant material in particular. More research is needed.

Literature |**1**| Mutthapa, B.N., 1985. Collar rot of aibika. Plant Pathology Note No 27. Harvest 11: 82–83. |**2**| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 464–473. |**3**| Powell, J.M., 1982. Traditional vegetables in Papua New Guinea: retrospect and prospect. In: Proceedings of the Second Papua New Guinea Food Crops Conference, July 14–18, 1980, Goroka. Department of Primary Industry, Port Moresby, Papua New Guinea. pp. 64–77. |**4**| Smith, E.S.C. & Thistleton, B.M., 1982. Some common pests of vegetables and fruits in Papua New Guinea and their control. In: Proceedings of the Second Papua New Guinea Food Crops Conference, July 14–18, 1980, Goroka. Department of Primary Industry, Port Moresby, Papua New Guinea. pp. 476–491. |**5**| Standal, B.R., Street, J.M. & Warner, R.M., 1974. Tasty, protein rich, and easy to grow – the new edible 'sunset' hibiscus. Hawaii Farm Science 2: 2–3. |**6**| Westwood, V. & Kesavan, V., 1982. Traditional leaf vegetables of Papua New Guinea: aibika. In: Proceedings of the Second Papua New Guinea Food Crops Conference, July 14–18, 1980, Goroka. Department of Primary Industry, Port Moresby, Papua New Guinea. pp. 391–395.

A.M. Gurnah

Allium ampeloprasum L. cv. group Leek

Sp. pl.: 294 (1753). Cv. group name proposed here.

LILIACEAE

$2n = 32$ (tetraploid)

Synonyms *Allium porrum* L. (1753), *A. ampeloprasum* L. var. *porrum* (L.) J. Gay (1847).

Vernacular names Leek (En). Poireau (Fr). Indonesia: bawang prei, bawang sayuran. Philippines: leek (Tagalog, Ilocano), sibuyas-bisaya (Bisaya), kuse (Pampangga). Cambodia: khtüm khchâl. Laos: pèènz fàlangx. Thailand: krathiam-ton (central), krathiam-bai. Vietnam: t[or]i t[aa]y.

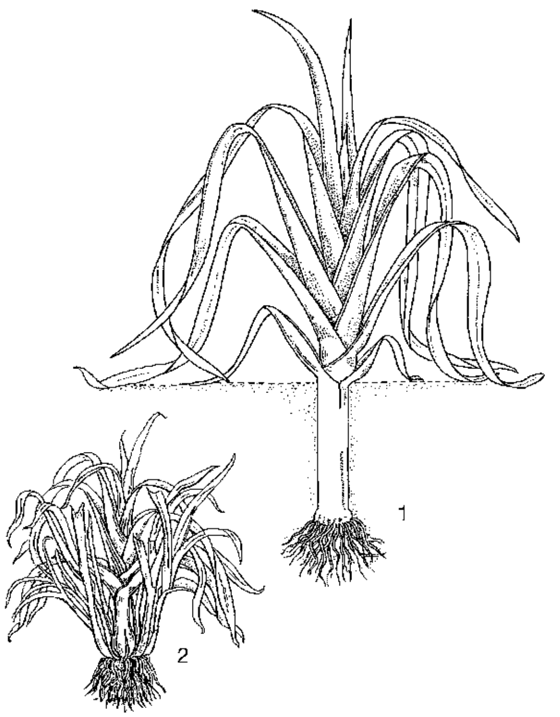
Origin and geographic distribution Leek is a cultigen derived from the wild *A. ampeloprasum* L. It is an ancient crop already mentioned in the Bible. Most probably it was domesticated in the eastern Mediterranean area where many of the related types (Turkish leek, kurrat, tareé irani) and related *Allium* species occur. Some other domesticated types are found far away from the centre of diversity: 'pearl onion' in Germany, 'poireau perpétuel' in France, 'prei anak' in Indonesia. Leek is a predominantly European crop, but has been widely distributed and is grown at higher elevations in the tropics. In Indonesia, it is particularly popular in East Java.

Uses The edible part is a pseudostem consisting of the elongated bases and lower blade parts of the foliage leaves, which is grown partly below ground to promote blanching. Leek is eaten as a cooked vegetable and as an ingredient of soups in the same way as welsh onion (*A. fistulosum* L.), e.g. as a component of bakmi (noodle dish).

Production and international trade Considerable acreages of leek are grown in France, Germany, Belgium, the Netherlands, the United Kingdom and Denmark, totalling about 25 000 ha. The small highland production in South-East Asian countries is not accounted for in official statistics. In Indonesia, leek is registered in the statistics as 'bawang daun' together with welsh onion. In the highlands of northern Sumatra (Berastagi), 'prei anak' is cultivated for export to Malaysia.

Properties The edible portion (etiolated pseudostem) is about 65% of the whole plant. Per 100 g it contains: water 90 g, protein 2 g, fat 0.3 g, carbohydrates 5 g, ash 1.5 g, Ca 60 mg, Fe 1 mg, P 30 mg, ß-carotene 0.6 mg, vitamin B_1 0.12 mg, vitamin C 0.03 mg. The corresponding energy value is 128 kJ/100 g. The 1000-seed weight averages 3 g.

Description Robust, biennial erect herb, 40–60 cm tall in the vegetative state, with little or no bulb formation, and a suppressed stem consisting only of a basal plate or disk. Adventitious roots appear at the base of the stem after the early loss of the primary root. Leaves 3–10, alternate in 2 opposite rows; blades linear, suberect or curved, 10–50 cm × 0.2–7 cm, flat or more or less V-shaped



Allium ampeloprasum L. cv. group Leek – 1, habit; 2, habit cv. group Prei Anak.

in cross-section; sheaths tubular, 5–50 cm long, longest in upper leaves; a young leaf emerges inside an older leaf forming a pseudostem consisting of old leaf-sheaths on the outside and young leaves inside. Scape 1, solid, terete, 40–150 cm long, exceeding the leaves; inflorescence a subglobose umbel bearing several hundreds of flowers, 4–12 cm in diameter, normally without bulbils, subtended by a single long-pointed spathe, which is shed at maturity; bracts absent, bracteoles numerous, membranous, 2–4 mm long, each subtending 1 flower; pedicel 1–5 cm long; flowers usually campanulate, purple or white; tepals 6, ovate-oblong, obtuse or acute, 4–6 mm long; stamens 6, exceeding the perianth; ovary with 3 locules, containing 2 ovules each. Fruit depressed globose to ovoid, 2–4 mm in diameter, containing up to 6 seeds. Seed 2–3 mm × 2 mm, black.

Growth and development Leek seed does not show rest or dormancy and germinates epigeally. Germination is rather slow; for 50% germination, a heat sum of 222 degree-days is required. Lateral bulbs are sometimes produced in the axils of the leaves, especially under long-day conditions after flowering. Flowering occurs only in plants larger than a certain minimum size, usually at the age of about 6 months. In the tropics flowers are seldom produced. Pollination is effected by insects and both self- and cross-pollination occurs. Bulbils ('topsets') are easily formed in the umbel, especially if flower buds are removed at an early stage of development. Seeds require high temperatures and long time to develop. Leek grows continuously, thus it can be harvested over a long period of time, starting about 4 months after transplanting of seedlings until flowering.

Other botanical information The taxonomy of *A. ampeloprasum* is rather confused. In the literature, the cultivated leek is most often named *A. porrum*. In *A. ampeloprasum* several cultivar groups can be distinguished, but their relations are not yet well known:

- Pearl Onion (sometimes classified as var. *sectivum* Lued.). Grown for the lateral bulbs, especially in western Europe. Plants lack pseudostems. Flowers white, but flower scapes are not regularly developed. They are very hardy.
- Great-headed Garlic (sometimes classified as var. *ampeloprasum*). Grown for the lateral bulbs, especially in western Asia and the eastern Mediterranean. Seed is not formed.
- Tarée Irani. Grown for its green leaves in Iran. The umbels form seeds and sometimes bulbils as well.
- Poireau Perpétuel. Occasionally grown for its leaves in France, Algeria and Greece.
- Prei Anak. Grown for its leaves in Indonesia, and possibly identical to Poireau Perpétuel. It is strongly tillering, producing up to 10 side-shoots. It has a firmer texture than the common European leek, and is propagated vegetatively.
- Kurrat (sometimes classified as var. *kurrat* Schweinf. ex Krause). Grown for its edible green leaves, especially in the Near East. The plant resembles a small leek, and is propagated by seed.
- Leek (as described here). Cultivars recommended for the tropics are 'American Flag', 'Broad Flat', 'Carentan', 'Early Market Colonna', 'Elephant', 'Italian Giant', 'Improved Musselburg', 'Prizetaker', 'Swiss Giant' and 'Goliath'.

Ecology The best temperature for growing leek is 20–25°C. In the tropics it is usually cultivated in the highlands at about 1000 m altitude. It is hardly affected by differences in daylength, except that long-day conditions are needed for the formation of lateral bulbs at the base of the flower stalk after flowering. Leek has greater cold tolerance than common onion. Does not require special soil types, except for a well-prepared loose top layer.

Propagation and planting Leek can be propagated vegetatively by means of topsets (bulbils formed in the umbel), by plantlets formed in the basal plate (from lateral buds or bulbs in the axils of the leaves) or most easily by means of the lateral bulbs formed at the base of the flower stalk after flowering. However, it is usually grown from seed, in South-East Asia necessarily from imported seed.
In Indonesia a special type of leek occurs, called 'prei anak' (leek with children). It grows normally, but readily forms sprouts in the leaf axils, resulting in a moderate-sized leek-like plant with up to 10 smaller side-shoots. At harvest, the small side-shoots can only be used for planting, so many of them are discarded.

Husbandry In the tropics, seed is usually sown in a shaded nursery. When 15–20 cm tall, the 2–3-month-old seedlings are transplanted to deep planting holes spaced 15–25 cm × 15–25 cm. Maturity is reached 120–150 days after transplanting. The longer the etiolated part of the pseudostem the better, and this is promoted by deep planting or earthing-up.

Diseases and pests In the tropics, leek suffers mainly from purple blotch (*Alternaria porri*), *Fusarium* and thrips (*Thrips tabaci*). They are usually controlled by spraying pesticides and by stringent crop rotation.

Harvesting Year-round cropping is possible. Harvesting is by uprooting.

Yield Yields are much lower in the tropics (5–15 t/ha of cleaned product) than in Europe (45 t/ha).

Handling after harvest After uprooting, roots are cut, outer damaged leaves are removed, and the remaining leaves shortened. For transport, the pseudostems are best put upright in baskets, leaves upwards. Leek has a limited storage period of 1–2 months at 0°C with a relative humidity of 90%, but storage and processing are still not common practices in the area.

Genetic resources Germplasm of leek and related types is available at the Institute of Horticultural Research, Wellesbourne (United Kingdom), the Centre for Genetic Resources, Wageningen (the Netherlands), and the Western Regional Plant Introduction Station, Pullman, Washington (United States). Nevertheless, severe genetic erosion of landraces has taken place in several European countries.

Breeding The major breeding objectives in Europe are productivity, uniformity and resistance to diseases, i.e. virus, rust (*Puccinia porri*) and white tip (*Phytophthora porri*). Resistance to white tip is rare or absent in leek, and this character is sought in wild relatives. Resistance to purple blotch would be very welcome in leek cultivars for the tropics. Most probably all commercial leek types are tetraploids with tetrasomic inheritance for most genes. The high rate of self-pollination results in a high percentage of inbreds, a considerable plant-to-plant variability within cultivars, and a considerable inbreeding depression.

Prospects Leek is not expected to become more important in the near future in the South-East Asian region since the use is the same as the more popular welsh onion (*A. fistulosum*). Studying the optimization of the production of vegetatively propagated leek ('prei anak') might be worthwhile.

Literature |1| Atanasov, N. & Carrazana, R., 1975. Formation of reproductive organs in leek in Cuban conditions. Revista de Agricultura Cuba 3: 94–102. |2| Rismunandar, 1986. Membudidayakan 5 jenis bawang [The cultivation of 5 Allium species]. Sinar Baru, Bandung, Indonesia. 116 pp. |3| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 14–16. |4| van der Meer, Q.P. & Hanelt, P., 1990. Leek (Allium ampeloprasum). In: Brewster, J.L. & Rabinowitch, H.D. (Editors): Onions and allied crops. Vol. 3. CRC Press, Boca Raton, Florida, United States. pp. 179–196.

D. Sulistiorini & Q.P. van der Meer

Allium cepa L. cv. group Aggregatum

Sp. pl.: 300 (1753). Cv. group Aggregatum: Jones & Mann, Onions and their allies. p. 31 (1963).

LILIACEAE

$2n = 16$

Synonyms
- Shallot: *Allium ascalonicum* auct. non Strand, *A. cepa* L. var. *ascalonicum* Backer (1951).
- Potato onion: *Allium cepa* L. var. *aggregatum* G. Don (1827), *A. cepa* L. var. *solanina* Alef. (1866).

Vernacular names Shallot, potato onion, multiplier onion (En). Echalote, oignon patate (Fr). Indonesia: bawang merah, brambang (Javanese), bawang beureum (Sundanese). Malaysia: bawang merah, bawang kecil. Papua New Guinea: lip anian. Philippines: sibuyas tagalog (Tagalog), lasona (Bisaya), cebollas (Bicol). Cambodia: khtüm krâhâm. Laos: hoom bwàx. Thailand: hom, homdaeng (central), hom-lek (central). Vietnam: h[af]nh ta, h[af]nh t[aw]m, h[af]nh n[es]n.

Origin and geographic distribution South-western Asia is the primary gene centre of *A. cepa*.

However, true wild plants do not occur. Based on the current natural distribution of its ancestral group (*A. oschaninii* O. Fedtschenko and its allies), it is assumed that the domestication of *A. cepa* started in Tadzhikistan, Afghanistan and Iran. The early history of the crop mainly relates to common onion forms. Shallot is derived from common onion by selection among naturally occurring variants, and the first reliable records of its existence date back to 12th Century France. Shallot spread around the world, presumably from Europe. It is now found from the equator to as far north and south as the polar circles. It is less important than common onion, except in the tropical lowlands at latitudes between 10°N and 10°S, where it predominates.

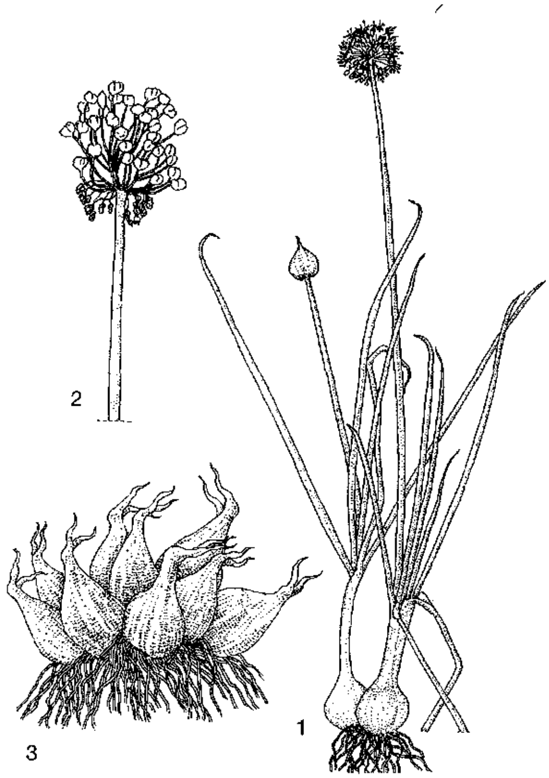
Uses Shallot (bulb) is used as food, spice and seasoning. It stimulates the appetite. It is often used raw, sliced, mixed with soy sauce and eaten with roasted meat. Shallot can be mixed with other ingredients and after grinding used as a spice for meat or fish. It is used for pickling, cooking and frying. Young inflorescences are a popular vegetable where the climate does not preclude bolting (e.g. northern Thailand, highlands of Indonesia).
Shallot also has medicinal properties. Traditionally it is used to reduce fever and to cure wounds. In the latter case the bulb is sliced, mixed with coconut oil and salt, boiled and placed as a poultice on the wound. Shallot is also used to lower blood sugar levels and inhibit platelet aggregation by eating it raw or cooked, as an extract or powder.

Production and international trade Shallot is economically an important crop in South-East Asia. Indonesian statistics indicate that 358 000 t shallots were produced from 65 000 ha in 1987; Thailand produced 239 300 t from 18 700 ha, and the Philippines produced 60 890 t from 7000 ha (including potato onion) in the same year. Shallot bulbs are traded fresh, fried or pickled.

Properties Per 100 g edible portion shallot bulbs contain: water 88 g, protein 1.5 g, fat 0.3 g, carbohydrates 9 g, fibre 0.7 g, ash 0.6 g, Ca 36 mg, P 40 mg, Fe 0.8 mg, vitamin A 5 IU, vitamin B_1 0.03 mg, vitamin C 2 mg. The energy value is 160 kJ/100 g. A high soluble solids content gives optimal quality for frying. In this respect 'Sumenep' is the best Indonesian cultivar, with a soluble solids content of 25–27°Brix. The range in other local and imported cultivars is from 15–20°Brix. Flavour and pungency also vary among cultivars and depend on the content of S-alk(en)yl cysteine sulphoxides.

The 1000-seed weight is 3–3.5 g.

Description A biennial herb, usually grown as an annual from bulbs, up to 50 cm tall. Roots adventitious, 1–2 mm in diameter, 10–25 cm long, arising from the true stem. True stem very short, flattened, formed at the base of the plant in the form of a disk; pseudostem formed by the sheathing bases of successive leaves. Leaves 3–8, alternate, distichous, glaucous, produced in succession from the broadening stem apex, each arising as a ring which elongates to form the tubular leaf-sheath; leaf-blade cylindrical, light to dark green in colour, hollow, erect or slanting. Bulbs formed by the thickening of leaf-bases a short distance above the true stem; as a result of the rapid formation of lateral bulbs or shoots, clusters of 3–18 bulbs of the first and second order are formed; protective bulbcoat-leaves purplish, brownish or white; mature bulbs oblongoid, globular or oblate, up to 5 cm in diameter, very variable in shape, size, colour and weight. Scape 1-several, up to 65 cm long, erect, straight, terete, at first solid, later becoming hollow. Inflorescence a spherical umbel,



Allium cepa L. cv. group Aggregatum – 1, flowering plants; 2, inflorescence; 3, mature bulbs.

2–8 cm in diameter, protected by a membranous spathe which splits into 2–4 persistent papery bracts; umbel with 50–2000 individual hermaphrodite flowers; pedicel slender; flowers subcampanulate to urceolate; tepals 6 in 2 whorls, ovate to oblong, 3–5 mm long, greenish-white; stamens 6; ovary superior, 3-locular, style simple, shorter than stamens at anthesis. Fruit a globular capsule, 4–6 mm in diameter, splitting loculicidally, containing up to 6 seeds. Seed about 6 mm × 4 mm, black, wrinkled.

Growth and development Shallot is commonly grown from a bulb containing 1–5 sprouts, each covered by scales forming separate concentric rings within the bulb. After bulb dormancy is over, the sprouts grow and emerge from the bulb, developing a cluster of 1–5 plants. New lateral shoots continue to develop resulting in a cluster of up to 18 plants after 7–8 weeks. Adventitious roots arise from the bases of the shoots. The leaves of each shoot grow successively from the very short true stem. The bases of the older leaves turn into sheaths covering the younger leaves, the blades of the older leaves ultimately die off and their sheaths form a pseudostem. At the time the top of the pseudostem lodges (7–10 weeks after planting), the plants have 4–5 leaf-blades only.

Bulbs are formed from the lower parts of the leaf-sheaths. This is the result of photosynthate mobilization from the leaf-blade to the base of the leaves. Bulbing starts from the outer leaf-sheaths, but as bulbing progresses, the leaf primordia form only fleshy scales (their blade development is aborted). When the bulb matures, the 3–4 outermost leaf-bases dry up, disappear or remain present as a papery skin. In the centre of the bulb, primordial sprout leaves are formed.

Under favourable environmental conditions, the apical meristem of the shoot ceases leaf production and bolts. The last internode of the true stem elongates, forming the flower stalk, which bulges in the lower part. *A. cepa* is a facultative cross-pollinator, the percentage of selfing amounting to 10–20%. Pollination is by insects. The cultivar groups Aggregatum and Common Onion are fully cross-compatible, bearing fertile hybrids.

Other botanical information The great infraspecific variability within *A. cepa* is nowadays considered to be divisible into two large horticultural groups:

- cv. group Common Onion: bulbs large, normally single, plants reproduce from seeds or from seed-grown bulbils (sets).
- cv. group Aggregatum: bulbs smaller, several to many forming an aggregated cluster, plants reproduce vegetatively via lateral bulbs (daughter bulbs).

The variability within cv. group Aggregatum is still insufficiently understood. The potato or multiplier onion (United Kingdom), the ever-ready onion (United Kingdom), the Russian vegetatively propagated onion, the 'Utrechtse Sint Jansui' (the Netherlands) and the 'griselle' (France) are considered to fall into this group together with the shallot. Clear distinction of those forms is often difficult, and it seems better to refer to them by cultivar names.

The so-called potato or multiplier onion is also grown in South-East Asia (e.g. in Indonesia, the Philippines and Thailand). It forms fairly large oblate bulbs with numerous laterals enclosed by the outer scales. These laterals produce separate tops and bulbs in their second year of growth, and the number of bulbs formed from a single bulb varies from 3 to 20. They differ from shallots (but many intermediate forms exist) in their larger bulb size, their often somewhat flattened shape, and usually having fewer daughter bulbs (of the first order only) which remain enclosed by the skin of the mother bulb for a longer period than in shallot.

The recent development of propagation of shallots by seed has reduced the usefulness of the current distinction of the two cultivar groups within *A. cepa*.

Ecology Tropical shallot requires an average day temperature of 20–26°C and a daylength of at least 11 hours, whereas common onion prefers slightly lower temperatures and a daylength of at least 13 hours. Shallot can grow in almost all types of soil with a pH higher than 5.6, but it prefers well-drained alluvial clay soil. In Indonesia 70% of the crop is grown in the lowlands below 450 m. It needs a lot of water, but very wet conditions can cause bulbs to rot.

Propagation and planting Shallot is commonly propagated by bulbs. Small bulbs of 4–5 g should be used, and to avoid problems of dormancy they should first be stored for 3–4 months. They are planted in beds of 1–1.2 m width and 0.6 m height with furrows of 0.4–0.5 m width between the beds. Planting distances vary from 18–20 cm between rows and 10–15 cm in the row. Planting must be shallow with the top of the bulb remaining visible.

Recent research indicates that propagation by means of seed is promising. It enhances the size and shape of the bulb and the health of the plant, and virus diseases are minimized. True seed is much cheaper than seed bulbs, but raising a crop from seed is more difficult. Yields are lower (mostly singles, i.e. only one bulb per plant) and quality is suboptimal (heterogeneous). If shallot is grown from true seed, seed is sown in a seed-bed at a rate of 25–50 g per 3–5 m^2, enough to plant 100 m^2; after 5 weeks the seedlings are transplanted to the field.

Husbandry Shallot is widely grown in paddy fields after the rice crop has been harvested. Common cropping patterns are rice-shallot-shallot(-shallot) or rice-shallot-capsicum pepper. Relay cropping with capsicum pepper is common practice in Central Java. One month after planting shallot, 4–6-week old capsicum seedlings are transplanted in between.

The recommended fertilizer rates for shallot in Indonesia, on alluvial clay after rice, are 10 t/ha of manure or 4 t/ha of compost, and 200 kg/ha of triple superphosphate as basal dressing during tillage. The second application at two weeks after planting consists of a mixture of 250 kg/ha of ammonium sulphate, 100 kg/ha of urea and 50 kg/ha of potassium chloride; the same mixture is side-dressed again two weeks later. If organic manure is hard to obtain, it may be substituted by the same mixture of inorganic fertilizer to be applied before planting together with the phosphate.

During dry weather, shallot has to be irrigated frequently (daily or even twice a day) by sprinkling 3–5 mm. Weeds are a serious problem and weeding by hand is done every 2 weeks.

Diseases and pests During the rainy season, purple blotch (*Alternaria porri*) and anthracnose (*Colletotrichum* sp.) are the main problems everywhere. Other fungal diseases are basal rot (*Fusarium oxysporum*) transmitted with the planting material, leaf blight (*Stemphylium* sp.), and to a lesser degree *Sclerotium* rot and neck rot (*Botrytis aclada*). Viruses observed in shallot are the aphid-spread onion yellow dwarf (poty)virus (OYDV) and shallot yellow stripe (poty)virus (SYSV). It is not known to what degree the viruses depress yield. The virus problem may be overcome by visually inspecting the planting material in the field and destroying any affected plants, or by the development of true-seed shallot cultivars.

In Indonesia the most serious pest problem in the dry season is army worm (*Spodoptera exigua*). The caterpillars hide inside the hollow leaves. Control is by hand picking and frequent spraying with insecticides. Thrips (*Thrips tabaci*) is reported to be a serious pest of shallot in Thailand.

Harvesting Harvesting takes place after the leaves have wilted, usually 60–70 days after planting in the lowlands, and 80–100 days in the highlands. The shallots are pulled out, tied into bunches of 1–2 kg and left to dry in the sun for 5–14 days (with the leaves on top to protect the bulbs).

Yield The average fresh shallot yield in Indonesia is 5.9 t/ha. Under optimal conditions, the best farmers may obtain a maximum of 18 t/ha. The dry season crop yields better than the wet season crop. The latter is often harvested in a premature stage, about 55 days after planting, because of severe fungal damage on the leaves. However, the net return from the wet season crop is higher because of fewer applications of insecticides and higher market prices.

Handling after harvest After drying, the shallots are tied into 2 kg bunches which are sold directly (80–90%) or stored as planting material (seed bulbs) for the next season (10–20%). The planting material is stored by hanging it on bamboo racks close to a fireplace. For long-distance transport, the dry leaves are cut off and the bulbs are transported in bags of 50–100 kg.

Genetic resources Vegetatively propagated shallot germplasm is maintained at the Hebrew University of Jerusalem (Israel) and the Lembang Horticultural Research Institute (LEHRI), Bandung (Indonesia); materials are mainly short-day cultivars. Long-day cultivars are maintained by the Research Institute of Vegetable Growing and Breeding, Olomouc (Czech Republic).

Breeding Local cultivars from Indonesia (Java, Bali, Lombok and North Sumatra), the Philippines and Thailand have been collected by the Lembang Horticultural Research Institute (LEHRI), Bandung (Indonesia). Evaluation of this germplasm collection led to the recommendation of some local cultivars, e.g. 'Bima', 'Maja Cipanas', 'Medan', and 'Keling'. A local cultivar from Thailand ('Sri Saket') is also popular in Indonesia ('Bangkok') for dry-season planting. Planting material (seed bulbs) imported directly from Thailand (Srisaket Horticulture Experiment Station) gives the best results. Breeding objectives are resistance to leaf diseases and improvement of bulb quality and yield. Sources of resistance are sought in related species, cultivated (*A. fistulosum* L.) as well as wild (*A. roylei* Stearn). Population improvement and hybrid development for shallot grown from true seed is receiving much attention. Consumers prefer red, round and large bulbs; for this purpose, crosses have been made between shallot and onion, with promising results.

Prospects Selection of virus-free planting material, improved disease control, better storage methods for consumption shallots, and commercial growing from true seeds seem to be feasible improvements in the near future.

Literature |1| AVRDC, 1988a. Vegetable research in South-East Asia. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. 242 pp. |2| Currah, L. & Proctor, F.J., 1990. Onions in tropical regions. Bulletin No 15. National Resources Institute, Chatham Maritime, United Kingdom. 232 pp. |3| Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 387–401. |4| Jones, H.A. & Mann, L.K., 1963. Onions and their allies. Botany, cultivation and utilization. Leonard Hill, London, United Kingdom. 286 pp. |5| Permadi, A.H., 1991. Penelitian pendahuluan variasi sifat-sifat bawang merah yang berasal dari biji [Preliminary study on the variation of characters in shallot grown from true seed]. Bulletin Penelitian Hortikultura [Horticultural Research Bulletin] 20(4): 120–131 (with English summary). |6| Rabinowitch, H.D. & Brewster, J.L. (Editors), 1990. Onions and allied crops. Vols. 1 and 2. CRC Press, Boca Raton, Florida, United States. 273 pp. and 320 pp.

Anggoro H. Permadi & Q.P. van der Meer

Allium cepa L. cv. group Common Onion

Sp. pl.: 300 (1753). Cv. group Common Onion: Jones & Mann. Onions and their allies. p. 31 (1963).

LILIACEAE

$2n = 16$

Synonyms *Allium cepa* L. var. *cepa*.

Vernacular names Onion, common onion, bulb onion (En). Oignon (Fr). Brunei: bawang besar. Indonesia: bawang bombay. Malaysia: bawang besar. Papua New Guinea: anian. Philippines: sibuyas (Tagalog), sibulyas (Ilocano), buliyas (Ivatan). Cambodia: khtüm barang. Laos: bwàx fàlangx. Thailand: hom-yai (central), hom-huayai (peninsular). Vietnam: h[af]nh c[ur], h[af]nh t[aa]y.

Origin and geographic distribution True wild *A. cepa* plants are not known. The ancestral group of *A. cepa* is considered to include *A. oschaninii* O. Fedtschenko and its allies *A. praemixtum* Vved. and *A. vavilovii* M. Popov & Vved. The current natural distribution of this *A. oschaninii* complex indicates that domestication of *A. cepa* probably started within contemporary Tadzhikistan, Afghanistan and Iran. South-western Asia can be acknowledged as the primary gene centre of variability. The earliest onion depictions originated in Egypt and date back to about 2700 BC; consequently, domestication must have begun much earlier.

Onion was introduced into western and northern Europe by the Romans about 300 AD. It became widespread in Europe during the Middle Ages and was introduced to the Americas by Columbus. It probably reached Japan in the 19th Century from the United States. It is almost impossible to trace its introduction to the tropics. Onions probably entered tropical East Africa from Egypt or India. Nowadays onions are cultivated almost worldwide at latitudes between 5–60° in both hemispheres. Onion growing is common in the Philippines and of some importance in Papua New Guinea and Thailand, but rare in the rest of South-East Asia. In Indonesia, Malaysia and other areas close to the equator, it is a difficult crop to grow, because of the troublesome storage of sowing seed, the rain damage to the nursery and the difficulty of producing healthy seed locally. Probably for that reason, vegetatively propagated shallots have become popular vegetables. Some shallot cultivars (e.g. 'Cipanas', 'Bali' and 'Bangkok') resemble small onions, but recently all vegetatively propagated onion and shallot types have been lumped together in the cv. group Aggregatum (see separate article); here, only the seed-propagated Common Onion group is described.

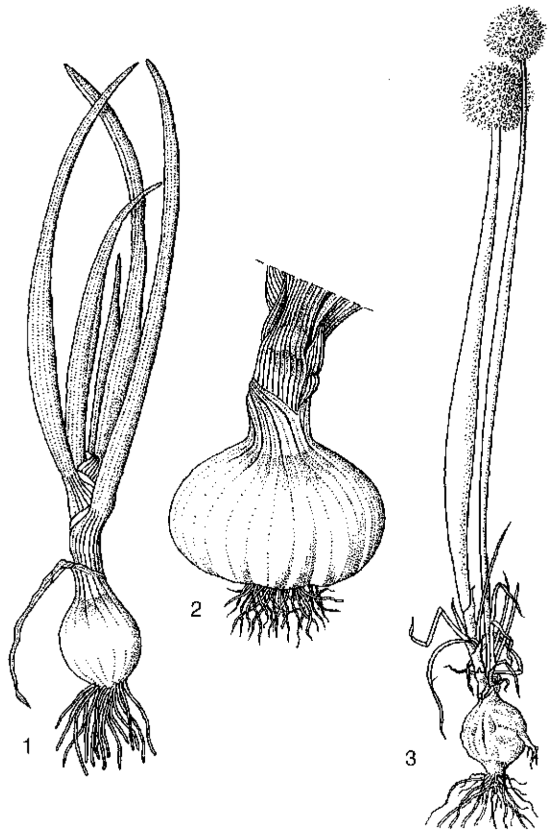
Uses The main characteristic of onion and other *Allium* crops is their pungency, and because of this they are probably the most indispensable culinary ingredient in the world. In general, they are used for salads (bunching onion or sliced full-grown bulbs), pickling (e.g. silverskin onions), cooking (e.g. in soups and Chinese dishes) and frying (e.g. with meat). In South-East Asia onions are normally eaten in cooked dishes like bakmi (noodles with meat). Onion also plays an important role in traditional medicine (e.g. as a diuretic). Recently its role in suppressing both the blood sugar level and platelet aggregation was revealed.

Production and international trade In 1989 the total world acreage under onions (including shallots) amounted to 1852000 ha producing 27142000 t. Over 2000000 t were traded internationally. In 1989 the Philippines produced 61000 t of common onion from 7000 ha, Thailand 41000 t from 2200 ha in 1988, whereas other South-East Asian countries produced very small amounts. A small part of the Philippine crop is exported to Japan. In 1988, Brunei imported 2100 t, Indonesia 5144 t (partly shallot), Papua New Guinea 2600 t, Malaysia 109520 t and Singapore 59376 t.

Properties The edible portion of mature bulbs is over 90%. The dry matter content varies between 7–20%. The chemical composition per 100 g edible portion is: water 89–93 g, protein 1–2 g and carbohydrates 5–9 g. The energy content varies from 95–150 kJ/100 g. The most important character of onion is the content of S-alk(en)yl cysteine sulphoxides which give rise to flavour and pungency. The pungency is expressed in mmol pyruvate per g fresh weight, the range being at least from 2 ('Imai Early Yellow') to 20 ('Mammoth Red'). The 1000-seed weight is 3–4 g.

Description A biennial herb usually grown as an annual from seed. All parts produce a strong onion odour when crushed. Roots adventitious, within a radius of 30 cm from the stem in the top 30 cm of the soil. Real stem very short, flattened, formed at the base of the plant; pseudostem formed by the sheathing leaf-bases. Leaves 3–8, alternate, distichous, glaucous, produced in succession from the broadening stem apex, each arising as a ring which elongates to form the tubular leaf-sheath; leaf-blade cylindrical, at first solid, later becoming hollow, up to 50 cm long, top acute. Bulb formed by the thickening of leaf-bases a short distance above the stem; outer leaf-bases thin, fibrous and dry, variously coloured, forming the protective bulb-coat; mature bulb (the onion) depressed globose to ovoid, up to 15 cm in diameter, very variable in shape, size, colour and weight. Scape 1-several, 30–100 cm long, usually exceeding the leaves, erect, straight, terete, hollow, often inflated in the middle or in the lower part. Inflorescence a spherical umbel, 2–8 cm in diameter with 50–2000 flowers, initially surrounded by a membranous spathe which splits to remain as 2–4 papery bracts; pedicel 1–4 cm long; flowers subcampanulate to urceolate; tepals 6 in 2 whorls, ovate to oblong, 3–5 mm long, greenish-white to purple; stamens 6; ovary 3-locular, style simple, shorter than stamens at anthesis. Fruit a globular capsule, 4–6 mm in diameter, splitting loculicidally, containing up to 6 seeds. Seed about 6 mm × 4 mm, black, wrinkled after drying.

Growth and development Onion seeds have hardly any dormancy. On germination the cotyledon functions as a haustorial organ, becoming green and photosynthetic and characteristically forming a sharp bend or knee on the soil. A primary root is produced by the seedling, all other roots are adventitious. After the seedling has established, approximately one new leaf is produced per week. When the plant has reached a certain stage of growth, and when the daylength is long enough and temperatures sufficiently high, a bulb is formed. Bulbing starts from the outer leaf-sheaths and ends up by the formation of some scales, i.e. thickened leaf-sheaths with aborted blades. The mature bulb consists of the disk (real stem), the skin (dry leaf-sheaths), false scales (fleshy sheaths of complete leaves), true scales (fleshy sheaths of leaves without blades), and primordial sprout leaves. When the bulb has reached full maturity (90–150 days after planting), the leaf-blades start to wither. After a dormant period of a few months, provided the temperature is favourable, the primordial sprout leaves emerge, the plants bolt and inflorescences are formed.



Allium cepa L. cv. group Common Onion – 1, habit; 2, basal part of plant with mature bulb; 3, flowering plant.

Onion is a facultative cross-pollinator, the percentage of selfing amounting to 10–20%. Flowers are protandrous. Pollination is done by bees, bumble-bees and glider flies. When mature, the fruits dehisce, causing shedding of seeds.

Other botanical information The great variability within *A. cepa* has led to numerous proposals for infraspecific groupings and hence the taxonomy is quite confusing. Presently, the simple informal classification into two cultivar groups is usually followed:
- cv. group Common Onion: bulbs large, normally single, plants reproduce from seeds or from seed-grown bulbils (sets).
- cv. group Aggregatum: bulbs smaller, several to many forming an aggregated cluster, plants reproduce vegetatively via lateral bulbs (daughter bulbs).

In the cv. group Common Onion numerous cultivars are available. Only the short-day cultivars are of interest for the tropics. In the Philippines 'Red Pinoy', 'Red Creole' and 'Granex' are grown. Thai farmers predominantly use 'Granex'. In Papua New Guinea 'Gladalan Brown', 'Awahia' and 'Superex' are important. In Malaysia only 'Red Creole' and 'Granex' are grown to a very limited extent.

Ecology Bulbing and maturing are earlier and faster under longer days, higher light intensity and, within certain limits, higher temperatures. Short-day onions which show normal bulbing and maturing under tropical conditions, in general exhibit too early bulbing and maturing at intermediate latitudes because of long days, and sometimes thick necks (pseudostem as in leek) because of low temperatures. Most tropical onions are grown during the dry season as too much rain will result in a high incidence of fungal diseases. Fertile alluvial mineral soils are preferred. In the tropics, onions grow well at varying altitudes; however, at elevations above 1000 m growth and development proceed relatively slowly and bolting percentages can increase. Besides the vernalization requirement (exposure of seed bulbs or growing plants to 5–10°C for one to two months), seed crops of tropical cultivars require high temperatures (20–30°C) and low relative humidity (below 70%). Seed production is therefore mainly carried out in the subtropics, especially in California (United States), where the climatic conditions are more favourable.

Propagation and planting Onion is propagated by seed. In hot humid climates, onion seed deteriorates quickly (within 3 months). In the tropics the seed is usually sown in a nursery under a mulch cover. After emergence, the mulch is removed. About 6–8 weeks after sowing, when the seedling has a base as thick as a pencil and is approximately 15 cm tall, the seedlings are transplanted to the field (transplant system). Occasionally, e.g. in Venezuela, small mature bulblets are planted (set system). A blueprint for onion cultivation at low latitude in South-East Asia is provided by the Philippines. Cultivars 'Granex' and 'Red Pinoy' are usually direct-seeded, whereas 'Red Creole' is transplanted. Direct seeding is carried out on beds at a relatively high density at the end of the rainy season (October-November). The beds, with 2 rows each, are separated by irrigation furrows. As soon as possible, the recommended density is realized by transplanting or thinning.

Husbandry Organic and/or chemical fertilizers are generally applied. High rates of NH_4^+-containing fertilizers should be avoided. Nitrogen should be applied at the beginning of the growth period in order to stimulate vegetative growth before bulbing. Watering is usually done by furrow irrigation. Mulching with rice straw is practised in some areas. Mechanization, with the exception of hand-sowing machines, is uncommon. Weeding and harvesting are mostly done by hand, although chemical weed control is increasing. Crop rotation is important to avoid the build-up of pests and diseases such as nematodes, *Sclerotium* and *Fusarium*.

Diseases and pests Severe losses from fungal diseases are very common; well known are *Alternaria porri* (purple blotch; control by e.g. dithane), *Fusarium oxysporum* (basal rot; control by crop rotation and resistance), *Stemphylium botryosum* (leaf-spot; control by e.g. carbamate), *Colletotrichum gloeosporioides* (anthracnose; control by e.g. benomyl), *Colletotrichum circinans* (smudge; only white cultivars are susceptible), *Aspergillus niger* (black mould on stored onions), and *Botrytis squamosa* (tip burn).

The most important pests in South-East Asia seem to be *Spodoptera exigua* (army worm) and thrips. Virus diseases, e.g. onion yellow dwarf and aster yellow, are not very common. Bacterial diseases such as *Pseudomonas aeruginosa* and *Erwinia carotovora* can cause considerable storage losses. Without adequate crop rotation, nematodes can be very harmful on upland soils at higher altitudes. Sunscald is caused by direct exposure to strong sunshine directly after harvest.

Harvesting Harvesting takes place 90–150 days after sowing. Open-pollinated cultivars do not mature uniformly, so priming is practised. The crop is pulled out by hand during the dry season (March – April in the Philippines), and remains for some days in the field with the bulbs covered by the leaves (= windrowing). The leaves are then cutt off and the mature bulbs are bagged or packed in crates if they are to be stored.

Yield For 'Granex', yield ranges from 15–20 t/ha and for red cultivars (which have a higher dry matter content) from 10–14 t/ha. These yields roughly correspond with the average world yield (14 t/ha in 1989), but are low in comparison with top yields of more than 50 t/ha at higher latitudes, e.g. in western Europe.

Handling after harvest The bulbs are normally packed in mesh bags or in crates of 20 kg. Storage for short periods is possible on racks in well-ventilated sheds. In the Philippines, part of the harvest of 'Red Creole' is kept in cold stores at 0°C for a maximum period of six months. 'Granex' has an inferior quality for storage and export.

Genetic resources Germplasm collections are maintained at the Institute of Horticultural Research, Wellesbourne (United Kingdom), the National Seed Storage Laboratory, Fort Collins, Colorado (United States), the Research Centre for Agrobotany, Tápiószele (Hungary), the National Institute of Agrobiological Resources, Tsukuba (Japan), and the Centre for Genetic Resources, Wageningen (the Netherlands).

Breeding Objectives are improvements in yield, quality, uniformity, keepability, resistance, and seed production in the equatorial tropics. Some characters (e.g. keepability) can be introduced from European or American cultivars. Recently improved prospects have appeared for transmitting resistance to downy mildew and anthracnose from *A. roylei* Stearn to *A. cepa*. A start has been made with seed production in the tropics, obtaining bulb vernalization in a cold store (Cuba) or by growing at altitudes of 1500–1800 m (Uganda).

Prospects The popularity of onion as an indispensable and popular culinary ingredient will undoubtedly increase. Its availability largely depends on adaptation to local ecological conditions, disease resistance and keepability. These objectives have not yet been met and as a consequence many tropical countries still import large quantities of onions from subtropical and temperate countries. In the near future, locally produced seed of well-adapted, keepable and disease-resistant cultivars of shallot-like kitchen quality will be in great demand. As soon as such cultivars become available for the equatorial zone, these will partly replace shallots because of the lower cost of the planting material. Close international collaboration between experienced onion researchers and breeders will greatly speed up developments.

Literature |1| Currah, L. & Proctor, F.J., 1990. Onions in tropical regions. Bulletin No 35. National Resources Institute, Chatham Maritime, United Kingdom. 232 pp. |2| Jones, H.A. & Mann, L.K., 1963. Onions and their allies. Botany, cultivation and utilization. Leonard Hill, London, United Kingdom. 286 pp. |3| Rabinowitch, H.D. & Brewster, J.L. (Editors), 1990. Onions and allied crops. Vols. 1 and 2. CRC Press, Boca Raton, Florida, United States. 273 pp. and 320 pp. |4| Rismunandar, 1986. Membudidayakan 5 jenis bawang [Cultivation of 5 Allium species]. Sinar Baru, Bandung, Indonesia. 116 pp. |5| Täckholm, V. & Drar, M., 1954. Flora of Egypt. Vol. 3, Allium. Cairo University Press, Cairo, Egypt. pp. 58–136. |6| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 20–23. |7| Tropical Development & Research Institute, 1986. Pest control in tropical onions. Tropical Development & Research Institute, London, United Kingdom. 109 pp. |8| van der Meer, Q.P. & de Vries, J.N., 1990. An interspecific cross between Allium roylei Stearn and Allium cepa L. and its backcross to A. cepa. Euphytica 47: 29–31.

Q.P. van der Meer & A.C. Leong

Allium chinense G. Don

Mem. Wernerian Nat. Hist. Soc. Edinb. 6: 83 (1827).

LILIACEAE

$2n = 32$ (tetraploid), seldom 16 (?)

Synonyms *Allium bakeri* Regel (1875).

Vernacular names Rakkyo (En). Indonesia: bawang ganda. Malaysia: lokyo. Thailand: krathi-am-chin (Bangkok), hom-prang (central), hom-paenyuak (northern). Vietnam: ki[eej]u.

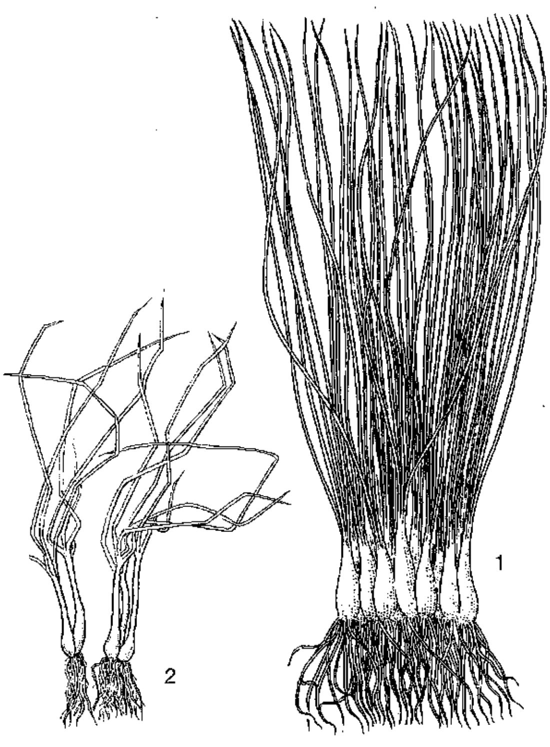
Origin and geographic distribution Rakkyo is native to central and eastern China. It is widely grown in China and Japan, to a limited extent in South-East Asian countries, and probably in private gardens of Japanese and Chinese people in many other parts of the world.

Uses The bulbs of rakkyo are mainly prepared as sweet or sour pickles after being steeped in brine for several days. In West Java they are also used raw and fried, often mixed with other vegetables. Medicinally it is of interest in the prevention of thrombosis.

Production and international trade Considerable production is restricted to China and Japan, which also export some of the crop. South-East Asia mainly imports rakkyo from Japan. Locally grown bulbs can be found in many markets in Indonesia (Java, Sumatra, Sulawesi) however.

Properties The edible portion, i.e. the swollen leaf-sheaths (bulb), constitutes approximately 30–40% of the full-grown plant before the leaves wither. It has the following constituents per 100 g: water 86 g, protein 0.6 g, carbohydrates 12.6 g, fibre 0.3 g and ash 0.2 g. The energy value is 215 kJ/100 g. Recently phenolic compounds were extracted from *A. chinense* in Japan. They inhibit blood platelet aggregation and thromboxane synthesis, which are two important components of the thrombosis process.

Description *A. chinense* is an unusual *Allium* species in that the leaves are hollow and the scape is solid (usually both the leaves and the scape are alike). A biennial herb, up to 60 cm tall. Bulb ellipsoidal, 2–4 cm × 7–15 mm, at top gradually tapering into the leaf-blades; protective bulb-coat leaves several, membranous, white to purplish; after planting, the bulb divides rapidly and forms a cluster of sprouting shoots which can divide again and finally produce new bulbs. Foliage leaves 3(–5), distichous, conical-cylindrical, 20–40(–60) cm × 1–5 mm, hollow, 3–5-ridged, D-shaped or nearly triangular in transverse section. Scape terete, solid, up to as long as the leaves and ca. 2 mm wide. Inflorescence umbellate, 6–30-flowered, without bulbils; spathe 2-lobed, persistent, hyaline; pedicel 1–3 cm long; flowers campanulate, purplish, tinged with red; tepals 6 in 2 whorls, 4–5 mm long; stamens 6, much longer than the tepals; inner 3 filaments with broadened bases and each with 2 short teeth; pistil much longer than the tepals; ovules 2 per locule.



Allium chinense G. Don – 1, habit after tillering; 2, mature bulbs.

Growth and development After planting, the growing point of a bulb divides to form a cluster of sprouting shoots and the number and weight of roots and leaves increase rapidly. After the shoots have reached a certain size, bulbs are formed, and the leaves wither and die. At intermediate latitudes (30–40° N and S), the flower stalk develops inside the bulb during the summer period, and in late summer the scape grows out of the old bulb whose leaves, by then, have already withered. The scape appears to stand outside the leaves as those are formed on new lateral bulbs. Since the flowers are female sterile, no seeds are produced. In the tropics, the full-grown crop remains small and development phases are much less pronounced than at intermediate latitudes; flowering is very rare in the tropics.

The rakkyo bulb resembles a small onion, but the bulb is formed by the thickened leaf-sheaths only and no bladeless scales are formed like those in the onion; consequently, no thin neck occurs.

Other botanical information Many cultivars of rakkyo exist in China and Japan. They can be broadly divided into small- and large-bulbed cultivars. Small-bulbed ones (e.g. 'Tama Rakkyo') produce 10–25 small bulbs (1.5–2.9 g) and large-bulbed ones (e.g. 'Rakuda') 6–9 bulbs (4–10 g). In Indonesia, several types occur differing in bulb size (from very small to small) and transverse leaf section ('D'-shaped and nearly triangular).

In older literature, in particular in Indonesia, the scientific name *Allium schoenoprasum* L. (chives) has been often misapplied to *A. chinense*.

Ecology The climatic requirements of rakkyo are not well known. Rakkyo is best adapted to intermediate latitudes (30–40°N and S). Long days (16 hours) promote bulb and flower formation. The optimal temperature range for bulb formation is 15–25°C. Photosynthesis decreases when the temperature increases from 15°C to 35°C, whereas transpiration increases. Rakkyo requires a well-drained soil, preferably not fertile (e.g. sand dunes). In fertile soils such as clay loam or volcanic ash, growth is too vigourous, resulting in too large and soft bulbs.

Agronomy Rakkyo is always propagated vegetatively by bulbs which are planted after a storage period of 1–2 months to overcome dormancy. Plants are usually spaced 10–15 cm × 10–15 cm. It is resistant to drought and can be grown without irrigation, but watering in dry months considerably increases yield.

Chlorosis is one of the major physiological diseases of rakkyo. It is caused by zinc deficiency; the symptoms are yellowish stunted plants with thickened leaves and distorted new leaves. Foliar applications of zinc sulphate can reduce the damage. The only pest reported is the *Rhizoglyphus* mite.

Rakkyo can be harvested from 45–60 days after planting. Harvesting is by hand, and bulbs are sold fresh in small bundles. Yields of 15–20 t/ha have been reported in Japan, but are much lower in the tropics. After harvest, the bulk of the crop is steeped in brine and subsequently processed into sweet or sour pickles. A fraction is kept as planting material for the next growing season.

Genetic resources and breeding Farmers' selections seem to be the only genetic resources available for further improvement. Collection of wild types has not yet been done. Breeding does not seem to be very urgent. An array of cultivars is available in China and Japan, but they do not set seed, since most cultivars are sterile tetraploids. Finding seed-producing selections could signal a breakthrough, as in garlic.

Prospects The ability to inhibit thrombosis seems to be of remarkable medicinal value. This, together with the medicinal reputation of the genus *Allium* in general, might further stimulate the interest in rakkyo as a vegetable as well.

Literature |**1**| Goda, Y. et al., 1987. Inhibitors of the arachidonate cascade from Allium chinense and their effect on in-vitro platelet aggregation. Chemical and Pharmaceutical Bulletin 35: 2668–2674. |**2**| Jones, H.A. & Mann, L.K., 1963. Onions and their allies. Botany, cultivation and utilization. Leonard Hill, London, United Kingdom. pp. 44–45, 60, 241–244. |**3**| Kunitomo, S. & Kosuga, M., 1960. Cultivation of rakkyo in Fukui District. Agriculture and Horticulture 35: 523. |**4**| Toyama, M. & Wakamiya, I., 1990. Rakkyo, Allium chinense G. Don. In: Brewster, J.L. & Rabinowitch, H.D. (Editors): Onions and allied crops. Vol. 3. CRC Press, Boca Raton, Florida, United States. pp. 197–218. |**5**| van der Meer, Q.P., 1990. The tropics as a natural entourage for cheap daylength research. Bulletin Penelitian Hortikultura [Horticultural Research Bulletin] 18 (special edition No 1): 81–89.

Q.P. van der Meer & L. Agustina

Allium fistulosum L.

Sp. pl.: 301 (1753).

LILIACEAE

$2n = 16$

Synonyms *Allium bouddhae* O. Debeaux (1877), *A. bakeri* Hoop. (1929), non Regel (1875).

Vernacular names Welsh onion ('welsh' probably derived from the German 'welsche' meaning foreign), (Japanese) bunching onion (En). Ciboule (Fr). Indonesia: bawang daun, bawang bakung (Sundanese), bawang oncang (Javanese). Malaysia: daun bawang. Philippines: buyah (Ifugao). Cambodia: khtüm sânlök. Thailand: hom-ton (central), hom-chin (peninsular). Vietnam: h[af]nh hoa, h[af]nh h[uw][ow]ng.

Origin and geographic distribution Welsh onion is only known in cultivation and probably originated in north-western China, although its ancestry remains unknown. The closely related wild species *A. altaicum* Pallas is still common in Siberia and Mongolia, where it is occasionally collected as a vegetable for local use or for export to China. Cultivation of the welsh onion dates back to at least 200 BC in China. It reached Japan before 500 AD and spread further to South-East Asia. The earliest description of the crop and its cultivation is found in a Chinese book of 100 BC. It is first mentioned in Japanese literature in 720 AD. Until the early 20th Century, the welsh onion was the most important *Allium* species in these countries, fulfilling the culinary role of both the common onion and leek in Europe. In Japan the welsh onion is now second in importance to *A. cepa* L., but in China, where welsh onion and common onion are used in different dishes, the welsh onion has retained its first place. The crop is grown throughout the world, but the main area of cultivation remains East Asia from Siberia to Indonesia. In other parts of the world it is mainly a crop of home gardens.

Uses The forms grown in East Asia for their thick, blanched pseudostems are eaten as a pot herb, e.g. in sukiyaki and chicken dishes. In

South-East Asia the welsh onion is mainly grown for its green leaves, which are used in salads, or as a herb to flavour soups and other dishes. In Java the plants are also eaten whole, either steamed or after heating over a fire for a short time. In Japan seedlings of 7–10 cm are used in special dishes. Welsh onion has not been used in a processed form until recently, when a dehydration industry started. The product is mainly used as an additive to preprocessed food such as instant noodles. The young inflorescence is sometimes deep-fried and eaten as a snack.

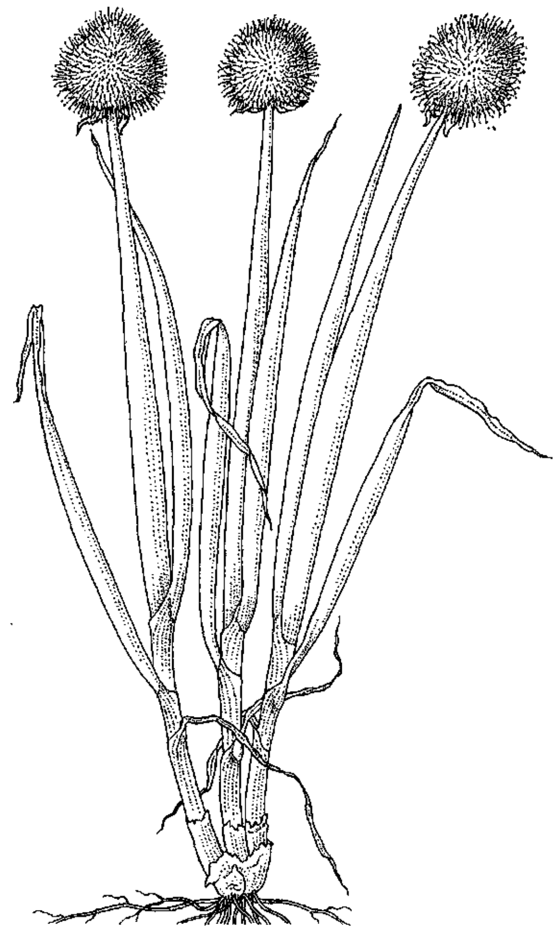
The plants are said to reduce or prevent white ant infestation in gardens. Diluted pressed juice is used against aphids in China. The therapeutic qualities attributed to the welsh onion are many, especially in Chinese medicine. It is used to improve the functioning of internal organs and the metabolism, and to prolong life. It is further reported to improve eyesight, to aid digestion and perspiration, and to enhance recovery from common colds, headaches, wounds and festering sores.

Production and international trade No worldwide statistics for the welsh onion are available, as information on its production is often combined with that of other *Allium* spp. Japan, Korea, China and Taiwan are the main producers. Production in Japan reached 563 000 t from 24 100 ha, in Korea 432 000 t from 18 900 ha (1984). Production in Indonesia in 1988 amounted to 163 000 t from 24 500 ha. International trade in welsh onion is very limited.

Properties The odour of the welsh onion is not very strong. It is chemically related to the odour of *A. cepa* and derives from volatile allyl-sulphides. The composition of green tops and blanched pseudostems differs, green tops being more nutritious. Green tops contain per 100 g edible portion: water 92 g, protein 1.7 g, fat 0.2 g, digestible carbohydrates 5.4 g, vitamin A 480 IU, vitamin B_1 60 mg, vitamin B_2 100 mg, niacin 400 mg, vitamin C 33 mg, Ca 80 mg, Fe 1.0 mg, K 200 mg, P 38 mg. The energy value is 105 kJ/100 g. A large proportion of the storage carbohydrates are sugars and oligosaccharides. Besides glucose, fructose and sucrose, they consist of maltose, rhamnose, galactose, arabinose, mannose and xylose. Sugar and protein contents increase in plants grown under low temperatures, and this improves eating quality.

The weight of 1000 seeds is 2.2–2.5 g.

Description Gregarious, perennial herb, often growing in large tufts, usually cultivated as an annual or biennial plant. Bulb indistinct, ovoid to oblongoid, up to 10 cm long, gradually passing into a more or less thick scape; lateral bulbs few to several, virtually absent in some cultivars, narrow and inconspicuous; protective bulb-coat leaves several, papery or chartaceous, smooth, reddish, purplish or brownish. Sproutleaf 1, of variable length, apex oblique; foliage leaves bluish-green with light bloom, distichous, glabrous, 4–6 in bunching types, 10–12 in single stem types, actively growing green leaves usually 3 and 5–6 respectively; blades tapering cylindrical, scattered in the lower part of the scape, (10–)30–150 cm × 1.0–2.5 cm, hollow, top acute, circular in cross-section. Scape 1, exceeding the leaves, erect, straight without localized swelling, hollow, 8–25 mm broad. Inflorescence umbellate, hemispherical to spherical, 3–7 cm across, composed either of flowers only or of bulbils only, flowering centrifugal;



Allium fistulosum L. – flowering plants.

spathe 1, hyaline, persistent, up to 10 mm long, acuminate, opening with (1–)2–3 slits into spathe valves; bracteoles absent; pedicels subequal to unequal, the lower ones shortest, 10–30 mm long; flowers narrowly campanulate to urceolate; tepals 6, ovate-oblong to oblong-lanceolate, 6–10 mm long, smooth, (greenish-)white, with greenish midvein, top acuminate; stamens 6, exceeding perianth; inner and outer filaments similar, 8–15 mm long, simple, narrow, also at base; anthers 1.5 mm long, yellow; pistil rather long, exceeding perianth; ovary globose to broadly obovate; style slender, 10–15 mm long. Fruit globose, about 5 mm across. Seed 3–4 mm × 2–2.5 mm, black.

Growth and development Welsh onion is a perennial plant, grown commercially mostly as an annual, in home gardens often as a perennial. It does not have a long-day dormant stage like *A. cepa*, so it continues its vegetative growth and does not develop a real bulb. However, some cultivars which originated from cold temperate areas show short-day dormancy, even when grown in warmer areas. They stop growing and their leaves dry out and die off under short days, even when the temperature would permit normal growth.

The lateral buds in the leaf axils elongate and develop as tillers to form a vigorous clump. This tillering characteristic is more pronounced in cultivars grown for the green leaves than in those grown for the long blanched pseudostems.

Flower induction is controlled by temperature and daylength. Low temperatures and short days induce flowering, but requirements vary strongly with the origin of cultivars. Flowering is generally induced by temperatures below 13°C, when seedlings have formed a certain number of leaves or a pseudostem of a certain thickness. Plants grown at 13–18°C bolt only under short days. When grown at 20°C and under a photoperiod of 16 hours, they are not vernalized. For certain Taiwanese cultivars like 'Pei Chung', 5 days at 5°C or 20 days at 10°C are sufficient for vernalization. In the tropics, where conditions favour vegetative rather than generative growth, only some well-adapted cultivars will flower.

Other botanical information Superficially there is a strong resemblance to *A. cepa*. Foliage leaves of *A. fistulosum* are somewhat rounder in cross-section, not flattened adaxially. Differences are more prominent in the inflorescence: *A. fistulosum* lacks bracteoles, has flowers about twice the size of *A. cepa*, the filaments of the stamens are more protruded, they lack basal teeth and are not broadened at the base. Moreover, *A. cepa* has a much better developed bulb.

A. fistulosum hybridizes readily with the related wild species *A. altaicum*. These hybrids have high pollen and seed fertility.

A. ×*wakegi* Araki (synonym: *A. fistulosum* var. *caespitosum* Makino) is a hybrid between *A. fistulosum* and *A. cepa* cv. group Aggregatum (shallot), with *A. fistulosum* as the female parent. It is a perennial plant forming small bulbs. Its inflorescence forms only bulbils, no fertile seeds. In the vegetative stage it is morphologically similar to *A. fistulosum*. Its leaves are slender, 60–70 cm long. One bulb may produce 20–30 tillers.

Other commercial hybrids between *A. fistulosum* and *A. cepa*, grown for their green tops, include 'Beltsville Bunching', 'Louisiana Evergreen', and 'Delta Giant'. These hybrids are fertile and normally propagated by seed.

The very large area of cultivation, the great adaptability to temperature and the varied uses of the crop have resulted in a very large number of cultivars. In Java three types of plants are identified:

- bawang bakung: robust plants grown for their pseudostem.
- bawang cina: meagre, strongly tillering plants, grown for their leaves.
- bawang daun: intermediate between the two and the most common type.

Popular Indonesian cultivars are 'Plumpung', 'Mambo', 'Nyonya', 'Siih Kecil' and 'Tosari'.

In Japan, four cultivar groups are generally discerned (system of Kumazawa):

- Kaga: this group has dark green thick leaves and pseudostems; they show little tillering and are grown for their pseudostems; the plants become dormant in winter.
- Kujyo: this group has tender, green leaves of excellent eating quality; they tiller profusely and are mostly grown for their green tops; they remain green during winter and their cold tolerance is generally low.
- Senju: this group is intermediate between the former two; they are mainly grown for their pseudostems, but growth continues during winter, although at a reduced rate.
- Yagura negi (*A. fistulosum* var. *viviparum* Makino): this group produces numerous tillers in spring and summer; its growth stops in winter, and it produces no flowers but only bulbils; it is propagated by division of the basal cluster or by bulbils.

Ecology Welsh onion is adapted to a remarkably wide range of climates. It is very tolerant of cold weather and can overwinter even in Siberia. It is also tolerant of hot humid conditions as occur e.g. in Bangladesh. In Java it grows well above an altitude of 200 m, but it is more common above 500 m. There are many local selections and commercial cultivars, reflecting the adaptation to this wide range of climatic conditions. Most cultivars are well adapted to variations in rainfall and more tolerant of heavy rainfall than other *Allium* spp. A well-drained loamy soil, rich in organic matter is preferred. Welsh onion is very susceptible to waterlogging, which quickly kills the active roots. Established plants are very tolerant of moisture stress and drought will rarely kill them.

For optimal growth a neutral soil pH is required, but even at a pH of 8–10 good growth is possible. In acidic soils growth is generally poor.

Propagation and planting In South-East Asia the crop is propagated mainly using basal tillers and can be planted the whole year round. Although seed production is possible at elevations above 1000 m, and imported seed of Taiwanese and Japanese cultivars is also available, plants are rarely raised from seed because this is more difficult under tropical conditions and is more time-consuming.

In temperate areas where seed production is more successful, propagation is mainly by seed, which is either sown directly into the field or first in nurseries. Seed requirements are 8–16 kg/ha for direct seeding and 2–4 kg/ha in the case of transplanting. In nursery beds, seeds are either broadcast or sown in rows or in 5–6 cm wide bands. The area of nursery required is 10–12% of the field area. Seedlings are ready for transplanting when 25–30 cm tall and thick as a pencil.

Husbandry In Indonesia welsh onion is planted on uplands as well as on dry paddy fields. For green leaf production, land preparation is light. Tillers are transplanted into raised beds or ridges, which are alternated with furrows for irrigation and drainage. Planting distances are about 20 cm × 25 cm (200 000 plants per ha). About one-third of the top part of the tiller is usually trimmed to reduce transpiration. Planting holes are filled with 50–100 g of manure (10–20 t/ha) and the shoots inserted slanting to stimulate tillering. Urea or ammonium sulphate at a rate of 3 g per plant (500–600 kg/ha) is applied 3 weeks after planting, and again at 6 weeks after planting if soil fertility is low. Weeding and earthing up are usually practised 6–7 weeks after planting. Welsh onion needs plenty of water. At lower elevations, it is usually grown during the rainy season. Daily irrigation is necessary during the dry season. Mixed cropping with white cabbage, carrot and potato is very common in the highlands.

For blanched pseudostem production, fields are deeply cultivated. Furrows of 10–20 cm deep are made, the soil being thrown to one side forming a ridge which will support the young plant and facilitate earthing up later. Earthing up is essential to blanch and soften the leaf-sheath cylinder. As earthing up also affects aeration and thus checks growth, it should be done gradually and not started too early.

Diseases and pests Although welsh onion is generally a healthy crop, it may be affected by a number of diseases, many of them common to most *Allium* crops. Purple blotch (*Alternaria porri*), which causes characteristic concentric spots on the leaves, and downy mildew (*Peronospora destructor*) may cause severe problems. White rot (*Sclerotium cepivorum*) may cause serious losses under successive or repeated cropping, as the pathogen is very persistent in the soil. Poor nutrition and heavy rains stimulate the development of the diseases. The practice of vegetative propagation in South-East Asia is conducive to virus infestation, but many of the landraces seem to be relatively tolerant. In addition, many diseased plants are removed by rigorous visual inspection of the planting material. The most important virus disease is caused by the onion yellow dwarf virus, which is transmitted by over 50 aphid species. It causes mosaic-type symptoms, including chlorotic mottling, streaking and stunting, and distorted flattening of the leaves. Relative tolerance is found in the Kujyo group of cultivars.

The beet army worm (*Spodoptera exigua*) and the American bollworm (*Heliothis armigera*) are the most serious pests. They are difficult to control due to the waxy layer on the leaves, and the fact that the larvae hide inside the hollow leaves. Onion thrips (*Thrips tabaci*) may cause considerable damage.

Harvesting In the tropics welsh onion can be harvested year-round. Plants are pulled out about 21/2 months after planting the tillers. The part used as planting material for the next crop is left in the field until it is needed. Harvesting is a labour-intensive operation, especially for pseudostems, which have to be dug up, cleaned and bundled. Mechanized harvesting equipment has been developed in Japan, which has reduced the labour requirements considerably.

Yield Average yields in Japan and Korea are about 25 t/ha, in Taiwan 10–15 t/ha. In Indonesia, they are considerably lower, averaging 7 t/ha, but also reaching levels of 15 t/ha; however, the growing period is only 2.5–3 months compared to 9 months in East Asian countries. Data for other countries are not available.

Handling after harvest After harvesting, leaves and pseudostems are cleaned, dried or damaged leaves are removed, and the plants are bunched and packed in boxes or baskets for transport to the market.

Genetic resources Collections of germplasm exist in Japan, the United States, the United Kingdom, Germany and the former Soviet Union. IBPGR ranked the welsh onion second in importance in the genus *Allium* because of its disease resistance, ecological adaptability and close relationship to *A. cepa*. Breeders often maintain their own collections and commonly exchange materials, thus maintaining an adequate level of variability.

Breeding In most countries farmers produce their own seed or planting material. In Japan a seed industry has developed, and some ten new cultivars are released per year. Breeders aim at improved cultivar homogeneity and adaptation to specific ecological conditions. For pseudostem cultivars, breeding work aims at obtaining lines with minimal tillering. Male sterile lines exist and F_1 hybrids have been developed.

Prospects The great adaptability of the crop and the example of Japan and Taiwan, where intensification of cultivation combined with selection, breeding and the development of a good marketing network has led to a greatly increased production, indicate that there is great scope for the development of better cultivars and for increased commercialization and intensification of production in South-East Asia too.

Literature |**1**| de Wilde-Duyfjes, B.E.E., 1976. A revision of the genus Allium L. (Liliaceae) in Africa. Mededelingen Landbouwhogeschool Wageningen 76-11: 87–89. |**2**| Helm, J., 1956. Die zu Würz- und Speisezwecken kultivierten Arten der Gattung Allium L. [Species of the genus Allium L. cultivated for use as condiment and vegetable]. Kulturpflanze 4: 130–180. |**3**| Inden, H. & Asahira, T., 1990. Japanese bunching onion (Allium fistulosum L.). In: Brewster, J.L. & Rabinowitch, H.D. (Editors): Onions and allied crops. Vol. 3. CRC Press, Boca Raton, Florida, United States. pp. 159–178. |**4**| Jones, H.A. & Mann, L.K., 1963. Onions and their allies. Botany, cultivation and utilization. Leonard Hill, London, United Kingdom. pp. 237–241. |**5**| Krug, H., 1991. Gemüseproduktion [Vegetable production]. 2nd edition. Verlag Paul Parey, Berlin, Germany. p 504. |**6**| Moore Jr, H.E., 1955. Cultivated Alliums. Baileya 3: 156–167. |**7**| Shinohara, S., 1980. Guidebook for development of vegetable horticulture with capable seed production in the monsoon subtropics. Shinohara's Authorized Agricultural Consulting Engineer Office, Tokyo, Japan. pp. 74–87. |**8**| Takamatsu, E., 1989. Leaf onion, Allium fistulosum. In: Shinohara, S. (Editor): Vegetable seed production technology of Japan. Vol. 2. Shinohara's Authorized Agricultural Consulting Engineer Office, Tokyo, Japan. pp. 260–287.

L.P.A. Oyen & Soenoeadji

Allium sativum L.

Sp. pl.: 297 (1753).
LILIACEAE
$2n = 16$

Vernacular names Garlic (En). Ail (Fr). Indonesia: bawang putih, bawang bodas (Sundanese). Malaysia: bawang putih. Papua New Guinea: galik. Philippines: bawang (Tagalog, Ilocano), ahos (Bisaya), ahus (Ibanag). Cambodia: khtüm sâ̂â. Laos: kath'ièm. Thailand: krathiam (general), hom-tiam (northern). Vietnam: t[or]i.

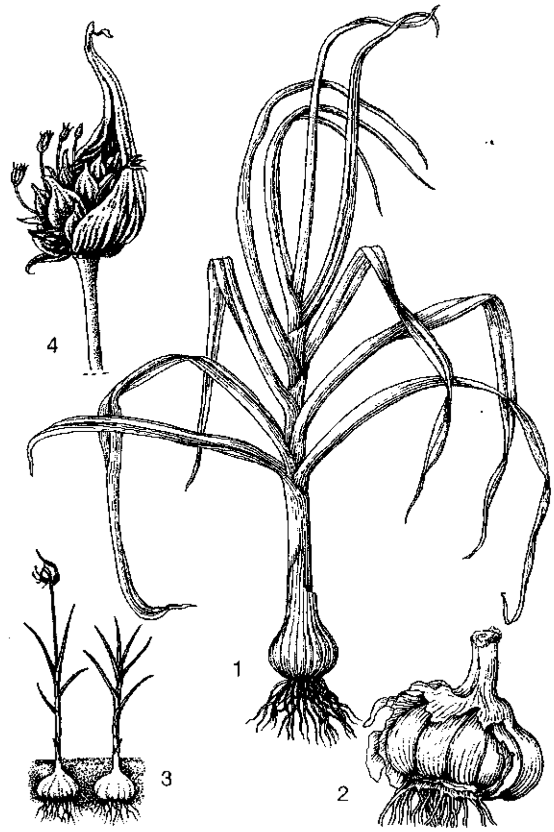
Origin and geographic distribution Garlic is only known from cultivation but is believed to originate from central Asia (Tien Shan), where its wild ancestor *A. longicuspis* Regel is endemic. Garlic spread to the Mediterranean region in ancient times, and was already known in Egypt in 3000 BC. It is an ancient crop in India and China as well. The Spanish, Portuguese and French introduced it to the New World. At present garlic is grown all over the world at latitudes between 5–50° in both hemispheres, but is most popular in the Mediterranean and in China.

Uses After onions, garlic is the second most widely used of the cultivated Alliums. It is mainly used as a condiment for flavouring meat, fish and salads, in fresh or dehydrated form. Apart from the mature bulbs, the green tops and immature bulbs are also widely used in Asia. Garlic is much valued as a medicinal crop. It has a strong reputation for lowering the blood sugar and cholesterol levels and inhibiting thrombus formation. Its many other attributed health-promoting activities are questionable, but have resulted in a rich supply of and demand for medicinal pills, drinks and powders based on garlic extracts. Garlic users extol its tasty and healthy qualities. Non-users abhor the offensive odour exhaled by users.

Production and international trade FAO estimates the 1990 world acreage at 469 000 ha with a production of 2 932 000 t. The leading producers are China (658 000 t), South Korea (417 000 t), India (280 000 t), Spain (202 000 t) and the United States (150 000 t). Thailand is listed by FAO with a production of 120 000 t, but Thai statistics report a production of 330 000 t from 31 000 ha in 1988. In that same year Indonesia produced 90 000 t from 16 000 ha, and imported considerable amounts from abroad. The Philippines produced 18 000 t from 6400 ha, and imported large amounts of dehydrated, powdered garlic from the United States, United Kingdom and Germany.

Properties The edible portion amounts to 50–70% of the total plant if used immature (pseudostem and immature bulb) or 20–30% if used mature (dry bulbs). The nutrient composition of dry bulbs per 100 g edible portion is: water 68 g, protein 3.5 g, fat 0.3 g, carbohydrates 27 g, ash 1 g, Ca 29 mg, P 202 mg, K 529 mg. The vitamin content is rather low. The energy content is 490 kJ/100 g.

The flavour is based on sulphur compounds, collectively referred to as S-alk(en)yl cysteine sulphoxides. Garlic is characterized by a dominance of S-allylcysteine sulphoxide (alliin) which is odourless but on crushing breaks down to allicin, the principal ingredient of which is the odoriferous diallyl disulphide.



Allium sativum L. – *1, habit; 2, bulb; 3, plantlets; 4, inflorescence.*

Description Erect herb, up to 60 cm tall, grown as an annual from small bulbs called cloves. Roots adventitious, superficial. Bulb depressed globular to ovoid, up to 7 cm in diameter, mainly composed of 1–15 sessile lateral bulbs (cloves) which have developed from axillary buds of the younger foliage leaves; protective bulb-coat leaves papery or chartaceous, smooth, whitish or purplish; cloves ovoid to ellipsoid-oblong, each consisting of a protective cylindrical sheath, a single thickened storage leaf-sheath and a small central bud. Real stem very short, flattened, forming a disk at the base of the bulb; pseudostem formed by the sheathing bases of successive leaves. Leaves 4–10, distichous, glabrous, scattered along the pseudostem; leaf-blade linear-oblong, up to 50 cm × 2.5 cm, flat or often V-shaped in section, margin smooth or crenulate, top acute. Scape 1, up to 1.5 m long, erect, straight, solid. Inflorescence a subspherical umbel, 2–5 cm in diameter, composed of only bulbils or of bulbils and flowers, protected by a membranous spathe that splits on one side when it opens; pedicels slender, up to 4 cm long; flowers subcampanulate, usually ill-developed, rudimentary or absent; tepals 6 in 2 whorls, lanceolate, acuminate, up to 3 mm long, greenish-pink to purple; stamens shorter than the tepals, arranged in 2 whorls; pistil more or less rudimentary, tricarpellate. Fruit abortive, without seeds.

Growth and development The propagule (clove) forms dorsi-ventral flat leaves from a central meristem situated on top of the clove disk (= true stem). Younger leaves emerge inside older ones, the leaf-sheaths forming a pseudostem. The top meristem ends its activity by forming a flower stalk or a last leaf.

A new clove develops from a lateral bud in the axil of the first or second foliage leaf of the mother clove. The bud (rudimentary side-shoot) consists of a rudimentary stem and leaf initials. The rudimentary stem develops into a new clove disk and the first two successive leaf initials into a swollen storage leaf and a protective skin. The following

5–6 leaf initials remain dormant until the next planting.

The garlic bulb normally consists of a number of cloves generated from as many lateral buds which are enveloped by the sheaths of the third and subsequent foliage leaves of the mother clove.

The duration of the subsequent growth and development phases strongly depends on the prevailing conditions. The total growing period varies from 3–4 months (in the tropics) to about 9 months (for winter garlic in temperate regions).

Other botanical information Garlic is an extremely variable species with many strikingly distinct cultivars (clones) known in cultivation. No satisfactory classification of the cultivars into groups exists, as too many intermediate cultivars remain unclassifiable. Nevertheless, two groups are often distinguished: cv. group Common Garlic (synonyms: *A. sativum* L. var. *sativum* and var. *typicum* Regel, *A. pekinense* Prokhanov) and cv. group Ophioscorodon (synonyms: *A. sativum* L. var. *ophioscorodon* (Link) Döll and var. *controversum* (Schrader) Moore, *A. ophioscorodon* Link). Cv. group Common Garlic has a straight scape and cv. group Ophioscorodon has a scape with a distinct curve or coil towards the top (the latter group is also known by the common names rocambole or serpent garlic).

Great-headed Garlic is a cv. group of *A. ampeloprasum*. It has the appearance of extremely robust garlic and is frequently confused with garlic. It may be readily distinguished by its large umbel without bulblets and the presence of small bulblets around the main bulb.

A. longicuspis, the presumed wild ancestor of garlic, is only collected from the wild and not cultivated. For garlic breeding, this species is promising because it can produce perfect flowers and good seed.

Because of a lack of breeding activities in the tropics, only local garlic strains are usually grown. Each region has its own cultivars. Indonesian strains are 'Lumbu Hijau', 'Lumbu Putih', 'Sanur' and 'Layur'. Philippine strains include 'Ilocos White', 'Ilocos Pink', 'Cabuyao' and 'Mindoro 1'.

Ecology Garlic growth is restricted to the temperature traject 9–28°C. Temperature and daylength are decisive factors for bulbing and bolting. For normal bulbing, exposure of propagules to 10–15°C for 2 months is required. Long days (> 12 hours) stimulate the formation of cloves. Lower temperatures (−2°C to 6°C) are needed for vernalization. Long days, low light intensity, drought and N deficiency hamper flower stalk development.

Garlic shows wide genetic variation in its response to temperature and daylength. This variation has been exploited for adapting the crop to all latitudes from the equator to 50°. Near the equator, garlic is grown in the highlands, since in the lowlands high day temperatures severely limit growth. On Java, garlic is grown from May until October, which corresponds with the dry season and conditions of relatively short days. As a rule of thumb, garlic should be grown at high altitudes in the tropics and during the prevailing long-day season, if possible.

Propagation and planting Garlic is normally propagated by cloves and seldom by big topsets (bulbils in the inflorescence). Dormancy lasts only 1–2 months, so dormancy-breaking is not normally necessary. In most areas in the tropics, e.g. Indonesia, garlic is planted once a year, and consequently the planting material has to be stored for 7–8 months. Optimum clove weight for planting depends on the cultivar. Planting cloves of about equal weight results in greater uniformity of maturity and size. Depending on the size (1.5–4 g per clove) and the plant density (50–70 plants per m^2), the quantity of planting material may vary from 750–2800 kg/ha. Planting distances are 15–20 cm between rows and 8–10 cm in the rows.

Husbandry The best field conditions are sole cropping on raised beds alternated with furrows. During the dry season, the crop has to be irrigated regularly. Planting, watering, weeding, harvesting are all done by hand.

The recommendations for fertilizer rates in Indonesia mention a basal dressing of 200 kg/ha of triple superphosphate during soil tillage. No organic manure is applied. A mixture of 80 kg/ha of urea, 80 kg/ha of ammonium sulphate and 50 kg/ha of potassium chloride is applied as side dressings at 15, 30 and 45 days after planting.

Diseases and pests The main problem for garlic growers is the control of purple blotch (*Alternaria porri*), especially during the rainy season. This disease is less of a problem at lower elevations. Growers spray regularly and intensively with fungicides. Healthy planting material, a modest N gift, and a lower planting density can reduce the disease. Other diseases often mentioned for garlic, but less troublesome in tropical areas, are basal rot (*Fusarium oxysporum*) and bacterial rot. Rust (*Puccinia porri*) and white rot (*Sclerotium cepivorum*) are less serious in the tropics than in temperate areas.

The main pest problems in Indonesia are army worm (*Spodoptera exigua*) and thrips (*Thrips* *tabaci*). Virus diseases probably severely depress yields. Onion yellow dwarf virus (OYDV) has infested the garlic crop almost everywhere (in Java for 87%). Leek yellow stripe virus (LYSV-G) is also very common in Java (ca. 19%). It is possible to produce virus-free plants by meristem culture, but for tropical conditions it seems more practical to visually select all planting material and rogue infected plants. This is common practice in several western countries.

Harvesting Harvesting takes place 3–4 months after planting, when the leaves start turning yellow and begin to dry up. Bulbs are pulled up and tied in bunches of several kg for drying and storage in sheds or kitchens.

Yield FAO figures (1988–1990) on yields per ha are 4–4.5 t for Indonesia, 3.5–4 t for Thailand and 2.5–3 t for the Philippines. These yields are low compared to the world average of 6 t/ha, and very low compared to data from certain subtropical countries such as Israel (10–12 t), Yemen (16 t), India (10 t) and Sudan (15–20 t). However, statistics from the Thailand Department of Agricultural Extension mention an average yield in Thailand of 10.6 t/ha in 1988. The Lembang Horticultural Research Institute (LEHRI) reported an average yield in Indonesia of 5.6 t/ha, with a potential yield of 12 t/ha.

Handling after harvest Garlic is transported in bunches, on strings, or in crates. It has a good keeping quality at a range of temperatures, −2°C being the optimum. Good ventilation during storage is essential.

Genetic resources Substantial germplasm collections of *A. sativum* are available in the Czech Republic, Israel and Spain. In Asia, important collections are held in Taiwan (Taiwan Agricultural Research Institute, Wufeng), India (National Bureau of Plant Genetic Resources, New Delhi) and Japan (Vegetable and Ornamental Crops Research Station, Ano). Smaller collections are available at research institutes in South-East Asia, e.g. LEHRI, Lembang, Indonesia.

Breeding Major breeding objectives are improved yields and better keepability, especially in tropical lowlands. When selecting for growing in the lowlands, the planting material should be stored at high altitude; if stored in the lowlands as well as grown there, the material is subjected to an unnecessary excessive high temperature stress, and the gap between genetic variation and adaption requirements seems to be unbridgeable.

Prospects For South-East Asia, several improvements seem very promising, i.e. better storage facilities (lower temperatures), and virus eradication by meristem culture and visual selection in the field. Screening of international germplasm collections, and possibly selection after generative multiplication, will yield improved planting materials.

Literature |1| Brewster, J.L. & Rabinowitch, H.D. (Editors), 1990. Onions and allied crops. Vol. 3. CRC Press, Boca Raton, Florida, United States. 265 pp. |2| Buijsen, J.R.M., 1990. Taxonomic survey of Allium species cultivated in South-East Asia. Mimeographed report. Rijksherbarium, Leiden, the Netherlands. 47 pp. |3| Etoh, T., 1985. Studies on the sterility of garlic, Allium sativum L. Memoirs of the Faculty of Agriculture, Kagoshima University 21: 77–132. |4| Jones, H.A. & Mann, L.K., 1963. Onions and their allies. Botany, cultivation and utilization. Leonard Hill, London, United Kingdom. pp. 36–38, 210–229. |5| Rismunandar, 1986. Membudidayakan 5 jenis bawang [Cultivation of 5 Allium species]. Sinar Baru, Bandung, Indonesia. 116 pp. |6| van Dijk, P., 1992. Virus diseases of garlic, shallot and welsh onion in Java, and prospects for their control. Report of CPRO-DLO, Wageningen, the Netherlands. 34 pp.

Q.P. van der Meer & Anggoro H. Permadi

Allium tuberosum Rottler ex Sprengel

Syst. 2: 38 (1825).
LILIACEAE
$2n = 32$

Synonyms *Allium odorum* auct., non L. (1767), *A. uliginosum* G. Don (1827), *A. senescens* Miq. (1867).

Vernacular names Chinese chives (En). Indonesia: kucai. Malaysia: kuchai. Philippines: kutsay (Tagalog), ganda (Bisaya), amput di imayyaw (Ifugao). Cambodia: kachaay. Thailand: kuichai (Bangkok), hom-paen (northern). Vietnam: h[ej].

Origin and geographic distribution Chinese chives is believed to have originated in China where it was certainly grown in the 10th Century and probably even as early as 200 BC. It grows wild in the central and northern parts of Asia, and is cultivated in China, India, Indonesia, Japan, Korea, Nepal, the Philippines, Taiwan, Thailand and the United States.

Uses Both the leaves and young inflorescences are used for seasoning food; they may be eaten blanched or green. They have a mild garlic taste and smell. Chinese chives is used medicinally against tumours, intestinal disorders, and in Thailand the seed is used against toothache. The plant is considered to promote recovery from fatigue.

Production and international trade Chinese chives is of considerable importance in China, Japan and Taiwan but in South-East Asia it is only a minor vegetable, mainly used in fried or cooked Chinese dishes. No statistics on production in South-East Asia are available; international trade seems to be negligible. In Indonesia it is only locally important, e.g. in Tangerang District (West Java). In Malaysia and Thailand it is more common.

Properties The leaves, forming 60–70% of the total weight, contain per 100 g edible portion: water 93 g, protein 2.1 g, fat 0.1 g, carbohydrates 2.8 g, fibre 0.9 g, ash 1 g, carotene 4 mg and vitamin C 25 mg. The energy value is 80 kJ/100 g. The antitumour activity is possibly related to the high carotene and vitamin C contents. The 1000-seed weight is 4–4.5 g.

Description A perennial herb forming dense clumps, 20–40 cm tall, with a prominently spreading rhizome from which thick long persistent roots emerge. Bulbs indistinct, narrowly ovoid, 15–20 mm × 15 mm, with several protective brown bulb-coat leaves broken up into netted fibres. Foliage leaves 4–9, distichous, linear, 13–45 cm × 2–10 mm, flat above, slightly keeled below, not folded lengthwise, suberect or curved. Scape 1, compressed, with 2 longitudinal ribs, up to 50 cm long, solid. Inflorescence umbellate, many-flowered, 3–5 cm in diameter, without bulbils; spathe short, persistent, opening with 1–3 valves; pedicels subequal, 14–35 mm long; flowers white, widely opened, star-like, slightly fragrant; tepals oblong to ovate, 6 mm × 3 mm; stamens and pistil up to as long as the tepals. Fruit obovoid, 5–6 mm long and wide. Seed irregularly depressed globose, 3–4 mm long, black.

Allium tuberosum Rottler ex Sprengel – 1, habit after tillering; 2, young inflorescences.

Growth and development Germination is epigeal, cotyledon with a typical bend (knee). The primary root dies early and many lateral roots originate from the very suppressed main stem, and, later, from the underside of the rhizome. Initially a rosette plant develops which later spreads via rhizomes, leading to dense clumps. Lateral vegetative bulbs, from which the plants also can perennate, form at the time of flowering in some cultivars. They are small, indistinct and white. Inflorescences initiate from terminal buds. Lateral bulbs in the axils of the leaves immediately below the inflorescence continue the growth of the vegetative axis (rhizome). Every 2–4 leaves the rhizome produces another inflorescence, altogether 2–4 per year. More than 90% of the seed develops apomictically.

Outside the tropics short photoperiods induce dormancy of buds which is broken by low temperatures; long photoperiods induce flowering. Under tropical conditions the growth is hardly or not interrupted by dormancy, and normally no flowering occurs.

Other botanical information Many cultivars have been developed, especially in Japan, China and Taiwan. They differ in leaf size, dormancy period, tillering and hardiness. 'Jumbo-Nira' is a Japanese cultivar with the longest dormancy period. In Indonesia several unnamed types occur, showing pronounced differences in leaf size and colour (light green versus dark green).

Ecology The optimum temperature for Chinese chives is about 20°C. In Indonesia it is grown in the highlands up to 2200 m altitude on fertile and loose soils. Under tropical conditions growth is not interrupted by dormancy or by flowering. Nevertheless, flowering occurs in cultivars grown in Malaysia and Thailand, and the markets are commonly supplied with inflorescences as well. Flowering can be induced by using incandescent light to create artificially long days.

Agronomy Outside the tropics Chinese chives is propagated by seed and in the tropics it is propagated vegetatively by division of clumps. In Indonesia it is mostly planted as a sole crop, but sometimes in combination with vegetables like amaranth and *Brassica* greens. When planted as a sole crop, plants are spaced at 15 cm in rows 40 cm apart. For home consumption, Chinese chives is often grown in pots. Leaves can be harvested 3–4 months after planting.

In China it is grown in trenches in order to induce blanching. To this end clumps of roots (stolons) are grown in darkness for the production of etiolated leaves. Inflorescences are usually harvested for consumption but may be maintained for seed production. Everywhere Chinese chives is a ratoon crop: leaves are harvested repeatedly from the same plants, in China even up to 20–30 years! Fertilizers are applied between harvests. The crop is renewed when the leaves become too small.

Chinese chives seems to be almost free from parasitic problems. It shows resistance to white rot (*Sclerotium cepivorum*), *Fusarium oxysporum* and leek moth (*Acroplepia assectella*). Only one pest (*Bradysia odoriphaga*) has been reported so far.

In the tropics Chinese chives is harvested the year round. Leaves are cut, bunched and marketed as fresh as possible. No yield data are available. As a rule the crop is grown close to the centres of consumption (big cities) and marketed as soon as possible. In fresh form it can only be stored for 2–3 days at 0–2°C. Cut finely, it is suitable for freezing.

Genetic resources and breeding The gene banks at the Zentralinstitut für Genetik und Kulturpflanzenforschung, Gatersleben (Germany) and at the Institute of Horticultural Research, Wellesbourne (United Kingdom) hold small collections.

In China, some selection of plants for seed production is done. In the tropics, selection is less easy because the vegetative propagation inhibits the generation of new genotypes.

Prospects Chinese chives, like garlic and onion, has an outstanding reputation as therapeutic and medicinal herb. This will undoubtedly stimulate its consumption in the future considerably. Consequently, breeding will deserve more attention. Artificial long-day treatment of Chinese chives in the tropics will be an easy way to produce seed and a large variety of genotypes as a starting point for selection and breeding.

Literature |1| Jones, H.A. & Mann, L.K., 1963. Onions and their allies. Botany, cultivation and utilization. Leonard Hill, London, United Kingdom. pp. 45, 61–62, 244–245. |**2**| Kosuga, T., Yokota, M., Sugiyama, K., Yamamoto, T., Ni, M.I. & Yan, S.C., 1985. Studies on antitumour activities and antitumour principles of Chinese herbs I. Antitumour activities of Chinese herbs [in Japanese]. Yakugaku Zasshi 105: 791–795. |**3**| Saito, S., 1990. Chinese chives, Allium tuberosum Rottl. In: Brewster, J.L. & Rabinowitch, H.D. (Editors): Onions and allied crops. Vol. 3. CRC Press, Boca Raton, Florida, United States. pp. 219–230. |**4**| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 30–31. |**5**| van der Meer, Q.P., 1990. The tropics as a natural entourage for cheap daylength research. Bulletin Penelitian Hortikultura [Horticultural Research Bulletin] 18 (special edition No 1): 81–89.

Q.P. van der Meer

Amaranthus L.

Sp. pl.: 989 (1753); Gen. pl. ed. 5: 427 (1754).

AMARANTHACEAE

$2n = 34$ (*A. tricolor*); $2n = 64$ (*A. dubius*); $2n = 32$ (*A. cruentus*)

Major species and synonyms

- *Amaranthus blitum* L. cv. group Oleraceus, synonyms: *A. lividus* L. (1753), *A. blitum* L. var. *oleraceus* (L.) Hook.f. (1885);
- *Amaranthus cruentus* L., Syst. pl. ed. 10, 2: 1269 (1759), synonyms: *A. paniculatus* L. (1763), *A. hybridus* L. ssp. *cruentus* (L.) Thell. (1912);
- *Amaranthus dubius* C. Martius ex Thell., Fl. adv. Montpellier: 203 (1912);
- *Amaranthus tricolor* L., Sp. pl.: 989 (1753), synonyms: *A. tristis* L. (1753), *A. mangostanus* L. (1755), *A. gangeticus* L. (1759).

Vernacular names Amaranth (En). Amarante (Fr). Indonesia and Malaysia: bayam. Papua New Guinea: aopa. Philippines: kulitis. Cambodia: phtii. Laos: hôm. Thailand: phakkhom-suan. Vietnam: rau d[eef]n.

Origin and geographic distribution The genus is widely distributed. Typical vegetable amaranths (*A. tricolor, A. dubius, A. blitum*) originated from South-East Asia but have been carried to other regions by emigrants. *A. cruentus* is originally a cereal amaranth from South and Central

America, currently grown as the main vegetable amaranth in Africa. By far the most important species in South-East Asia is *A. tricolor*, followed by *A. dubius* and *A. cruentus*.

Uses The main use is as a leafy vegetable. It is very common in the whole of South-East Asia, more in lowland than in highland areas. With kangkong (*Ipomoea aquatica* Forssk.) it is the most popular leafy vegetable of Indonesia and Malaysia. It is an important vegetable in many tropical countries, for example in India, Bangladesh, Sri Lanka, Tanzania, Uganda, Nigeria, other West African countries and the Caribbean. Various amaranth species with light-coloured seeds, such as *A. hypochondriacus* L., *A. cruentus* and *A. caudatus* L., are traditionally grown as a minor cereal crop in Central America, South America, India and Nepal in mountain areas as well as at low altitudes. Thinnings of young seedlings from the cereal crop are frequently used as greens. Many wild *Amaranthus* species are used as pot herbs. Used as ornamentals are *A. tricolor* forms with red, yellow and green-coloured leaves or leaf sections, and *A. caudatus* and *A. cruentus* with large bright-red inflorescences. *Amaranthus* weeds are used for fodder (pigweed). Vegetable amaranths are recommended as a good food with medicinal properties for young children, lactating mothers and for patients with fever, haemorrhage, anaemia or kidney complaints. The wild *A. spinosus* L. is used as a depurative, against venereal diseases and as a dressing on boils.

Production and international trade Although considered a poor man's food, its economic value as a popular vegetable probably ranks among the ten highest in South-East Asia. Few exact economic data are available, since in most cases all leaf vegetables are recorded as one single group. Indonesian statistics in 1988 attributed 22 000 ha to amaranth grown for the city markets. Correct registration is hampered by the short growing period (3–6 weeks), scattered occurrence of small plots of cultivation, and the dispersed sales in small street markets. Amaranth is widely grown on a small scale in home gardens and open places in between field crops.

Properties Amaranth leaves have a high content of essential micro- nutrients. They are an excellent source of ß-carotene with 4–8 mg per 100 g edible portion, vitamin C 60–120 mg, Fe 4–9 mg, and Ca 300–450 mg. They are rich in fibre and folic acid and their protein content (20–38% based on dry matter) includes methionine and other sulphur-containing amino-acids. The general dry matter content is high (12–16%). The leaves and stems have nitrate and oxalate levels similar to other green leaf vegetables such as spinach (*Spinacia oleracea* L.) and spinach beet (*Beta vulgaris* L.), but no adverse nutritional effects occur with a consumption of 100–200 g per day. The composition varies greatly with cultivar, soil fertility, water supply, and age at harvest. The higher the plant nutrition (N, P, K, etc.) the better the yield and the nutritional composition (especially iron, vitamin A and C). However, excessive N fertilization may result in an unacceptable high nitrate level. The weight of 1000 seeds varies from 200–850 mg.

Description

– *Amaranthus*. Erect annuals, strongly branching, up to 2.5 m tall, with a strongly branched taproot. Leaves alternate, long-petiolate, simple and entire. Flowers in axillary clusters, upper clusters often leafless and in panicled spikes, unisexual, solitary in the axil of a bract, with 2 bracteoles, 3–5 tepals and either free stamens, as many as tepals (male flowers), or ovate or ob-

Amaranthus tricolor L. – flowering and fruiting shoot.

long ovary with 2–3 (–4) stigmas (female flowers). Fruit a dry capsule, dehiscent or indehiscent. Seeds shiny black or brown.

- *A. tricolor*. Erect annual, up to 1.5 m tall. Leaves elliptical to lanceolate or broad-ovate, dark green, light green or red. Clusters of flowers axillary, often globose, with a reduced terminal spike, but occasionally the terminal spike is well developed. Tepals 3. Fruit dehiscent, with a circumscissile lid. Seeds black, relatively large; 1200–2900 seeds/g. Cultivated.
- *A. dubius*. Annual, sometimes biennial, up to 2 m tall, erect, strongly branching. Leaves ovate or rhomboid-ovate, shortly cuneate at base, dark green. Lower clusters of flowers axillary, upper clusters leafless and in lax panicled spikes. Tepals (3–) 5. Fruit dehiscent, with a circumscissile lid. Seeds black, very small; 3000–4800 seeds/g. Cultivated vegetable, sometimes escaped as weed.
- *A. cruentus*. Tall annual, up to 2.5 m. Leaves lanceolate, acute and often short-decurrent at base, greyish-green. Clusters of flowers in large axillary and terminal panicled spikes. Tepals 5. Fruit dehiscent, with a circumscissile lid. Seeds dark brown to black; 2500–3000 seeds/g. Seeds of grain types are light yellow. Cultivated as vegetable or grain.
- *A. blitum* cv. group Oleraceus. Small annual, up to 75 cm tall. Leaves (ob)ovate or rhomboid-(ob)ovate, shortly cuneate at base, green or more or less purple. Lower clusters of flowers axillary, upper clusters leafless and in axillary and terminal panicled spikes. Tepals 3 (–5). Fruit indehiscent or finally bursting irregularly. Seeds small, dark. Weed, sometimes cultivated. It is a popular cultivated vegetable in India.

Growth and development Emergence takes place 3–5 days after sowing and vegetative development is fast. Depending on cultivar, photoperiod and cultural practices, flowering may start 4–8 weeks after sowing, making the plant less suitable for consumption. There are at least four times as many female flowers as male flowers. Pollination is effected by wind but the abundant pollen production, especially in the higher flowers, causes a high rate of self-pollination. Outcrossing is 0–40%. In *A. tricolor* and *A. cruentus*, the seeds mature after 3–4 months and then the plant dies. *A. dubius* will continue its generative stage for a much longer period and when cut regularly, the plant may become shrubby and perennial, but even at its mature stage, the leaves are succulent enough for consumption. These plants can be found in Indonesia in home gardens.

Other botanical information The taxonomy of the genus *Amaranthus* is still confused. Moreover, names such as *A. hybridus* L. are often erroneously used to describe vegetable amaranths. The commercially grown amaranth in South-East Asia is mostly *A. tricolor*. There are numerous landraces. Some cultivars are available from Indian, Taiwanese and other seed companies. Cultivars are distinguished by characteristics such as leaf form and colour, leaf/stem ratio, succulence, growing vigour, tolerance of fungal diseases, susceptibility to insect attack, drought resistance and photosensitivity. *A. cruentus* is the most resistant to adverse climate and soil conditions.

Two different types of plants of *A. blitum* are distinguishable. Comparatively small and ascending plants are found as a weed. Large, erect plants are cultivated and are referred to as *A. blitum* cv. group Oleraceus.

Besides these cultivated types, several wild species are occasionally collected as pot herbs, i.e. *A. viridis* L. (synonym *A. gracilis* Desf.), *A. spinosus*, *A. retroflexus* L., and *A. hybridus*. In South America, India and Nepal, the young plants of the grain type *A. hypochondriacus* are used as a vegetable.

Ecology Like maize and sugar cane, the genus *Amaranthus* is characterized by the C4-cycle photosynthetic pathway, which means a high photosynthesis at high temperature and radiation. Vegetable amaranths grow well at day temperatures above 25°C and night temperatures not lower than 15°C. In Indonesia, the temperature is too low above 800 m for *A. tricolor*, causing growth retardation. However, *A. cruentus* and *A. dubius* are found up to 2000 m. Shade is disadvantageous except in cases of drought stress. Amaranths are quantitative short-day plants, which is an advantage in the subtropics where the generative stage is retarded during summer. Because of rapid growth, water consumption is high. A crop normally uses about 6 mm/day. Amaranths like fertile, well-drained soils with a loose structure. The mineral uptake is very high.

Propagation and planting Amaranth is a vegetable for small labour- intensive farms of rarely more than 0.25 ha. The most common practice is sowing directly in rows with 10–20 cm between the rows, or broadcasting, with a seed rate of 2–5 g/m^2 (20–50 kg/ha). If transplanted, the seed requirement is only 2 kg/ha. Plant densities of 400 plants/m^2 for harvesting by uprooting or once-over cutting, and of 100 plants/m^2 for repeated clippings are considered as maximum. Higher densities result in self-thinning without giving higher yield. Amaranth is normally grown commercially as a sole crop on beds. It is also found in intercropping systems with food crops, in particular in Africa.

Husbandry Because of the strong growth of amaranth, weeds are not very troublesome, except nut grass (*Cyperus rotundus* L.). Usually no weeding is necessary. If rainfall is not sufficient, irrigation by sprinkling should be done before the plants reach their wilting point. Watering every day with 8 mm (8 l/m^2) is generally sufficient. With a normal yield of 25 t/ha in 8 weeks, about 125 kg N, 25 kg P, 250 kg K, 75 kg Ca and 40 kg Mg may be taken up per ha. Larger quantities of N and K are easily absorbed as luxury uptake if these elements are abundant. Amaranth responds to high rates of organic fertilizer. In some places it is grown on large quantities (up to 50 t/ha) of almost fresh town refuse, which fulfils its need for minerals. On poor soils, the application of 400 kg/ha of NPK (10–10–20) in addition to 25 t of organic manure is recommended. A split application is recommended during the rainy season. Nitrate-N is better than ammonium-N. It seems that amaranth does not need to be rotated with other crops since no serious soilborne disease has been observed. Many growers cultivate amaranth continuously on the same beds.

Diseases and pests Damping-off caused by *Pythium* may be serious in seed-beds. It is controlled by good drainage and over-dense sowing should be avoided. Fungicides like dithiocarbamates have some effect. White rust caused by *Albugo candida* is reported as a minor problem. Wet rot caused by *Choanephora cucurbitarum* is the main disease on *A. cruentus*, but *A. tricolor* and *A. dubius* are not very susceptible to this fungus.

Insects are a serious problem for amaranth growers. Caterpillars (*Spodoptera litura, Heliothis armigera, Hymenia recurvalis*) and grass hoppers are the most harmful. Many other insects such as borers, aphids, leafminers, stinkbugs, mole crickets and spint mites also attack amaranth. The more primitive traditional method of spreading wood ash to dispel insects has been replaced by spraying regularly, up to twice a week, with insecticides. In order to avoid harmful residues, the use of less toxic chemicals is strongly recommended (for example, bromophos, carbaryl, pyrethroids). Thuricide is effective against caterpillars.

Harvesting The whole crop is harvested 3–4 weeks after sowing by uprooting all at once or by cutting at ground level. Another method is harvesting by repeated cuttings every 2–3 weeks (ratooning). In this case, the best planting method, at least for *A. dubius*, is rather wide spacing of about 20 cm × 20 cm and cutting at a height which leaves behind at least 2 leaves and buds for regrowth. The height of the first cut is normally 10–15 cm. Low cutting retards bolting. Up to 10 cuts may be obtained at weekly or two-weekly intervals.

Yield Yield averages 1–2 kg/m^2 (edible portion). Continuous cropping of amaranth may yield at least 12 kg/m^2 per year. In *A. tricolor* and *A. dubius*, growth is less vigorous and yields are lower than in *A. cruentus*. The optimal harvest period is reached when the total leaf area is 7 times the ground area (LAI = 7). But the yield is often lower because the crop is harvested at a very young stage for a more tender product.

Handling after harvest Amaranth wilts rapidly. In markets and shops, it is sprinkled with water to keep a fresh appearance. If uprooted, the vegetable can be kept fresh for some days by putting it in a basin with the roots in the water. It is sold in bunches per unit of money or by weight.

Genetic resources Collections of amaranths are kept at the Rodale Organic Gardening and Farming Research Center (OGFRC) at Kutztown, Pennsylvania (United States); South-East Asian accessions are kept at the Asian Vegetable Research and Development Center (AVRDC) at Tainan (Taiwan), and Indian collections at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi (India). Indonesian cultivars are available from the Lembang Horticultural Research Institute (LEHRI).

Breeding In some countries (Indonesia, Taiwan, India, Benin) selections have been made from local landraces. Popular cultivars are 'Klaroen' (*A. dubius*), which originates from Surinam (South America), and 'Fotete' (*A. cruentus*), a productive cultivar from Benin (West Africa). Well-known cultivars of *A. tricolor* are 'Katwa Data', 'Lal Sag' and 'Co.2' and 'Co.3' from India. The 'Co.' cultivars come from Tamil Nadu University in Coimbatore (India), where researchers work on intervarietal hybridization and polyploidy. 'Co.2' is a cultivar for pulling, 'Co.3' for clipping. Both have a high leaf/stem ratio of more than 2. In Taiwan, seed companies sell 'White Leaf', and in Indonesia cultivar 'Giti Hijau' has been selected from Taiwanese material.

Prospects Amaranth is recognized as an easy-to-grow and very productive crop. It is probably the highest-yielding leaf vegetable of the tropics. Its excellent nutritional value makes it an important vegetable for human nutrition, both in rural areas for home consumption and as a cheap green vegetable in city markets. Research should focus on optimization of cultural practices (effective pest control with fewer residues, plant nutrition).

Literature |1| Grubben, G.J.H., 1976. The cultivation of amaranth as a tropical leaf vegetable. Communication 67. Royal Tropical Institute, Amsterdam, the Netherlands. 207 pp. |2| Grubben, G.J.H. & van Sloten, D.H., 1981. Genetic resources of amaranths: a global plan of action. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 57 pp. (including a provisional key to some edible species of the family Amaranthaceae, by Laurie B. Feine-Dudley). |3| Kauffman, C.S., & Gilbert, L., 1981. Vegetable amaranth summary. Rodale Press, Emmaus, Pennsylvania, United States. 30 pp. |4| National Research Council, 1984. Amaranth, modern prospects for an ancient crop. National Academy Press, Washington, DC., United States. 80 pp. |5| Proceedings of the Second Amaranth Conference, 1980. Rodale Press, Emmaus, Pennsylvania, United States. 184 pp. |6| Senft, J.P., Kauffman, C.S. & Bailey, N.N., 1981. The genus Amaranthus: a comprehensive bibliography. Rodale Press, Emmaus, Pennsylvania, United States. 217 pp. |7| Shanmugavelu, K.G. & Kader Mohideen, M., 1989. Accomplishments in amaranth research at the College of Horticulture, Tamil Nadu Agricultural University. Amaranth Newsletter 3: 5–7.

G.J.H. Grubben

Apium graveolens L.

Sp. pl.: 264 (1753).
UMBELLIFERAE
$2n = 22$

Synonyms *Apium dulce* Miller (1768), *A. rapaceum* Miller (1768), *A. lusitanicum* Miller (1768).

Vernacular names Celery, stalk celery, leaf celery, celeriac (En). Céleri côte, céleri branch, céleri rave (Fr). Indonesia: selederi, saledri. Malaysia: sadri, selderi, seladeri. Philippines: kinchai, kinintsai, kinsay. Cambodia: chii tang' 'aô, kiën chhaay. Laos: s'ii s'aangz. Thailand: khunchai (central), phakpum (northern), phakkhaopun (northern). Vietnam: rau c[aaf]n t[aa]y.

Origin and geographic distribution *Apium graveolens* occurs wild (var. *graveolens*) as a marsh plant throughout temperate Europe and Asia (water celery). Even before the Christian era it had been brought into cultivation, first as a medicinal plant, later for the leaves (leaf or cutting celery) which were used as a flavouring (var. *secalinum* Alef.). It was, however, only in the 16th or 17th Centuries that milder-tasting special forms were selected in France or Italy for use as vegetable: stalk celery with large, swollen petioles (var. *dulce* (Miller) Pers.), and celeriac with a turnip-like edible tuber (var. *rapaceum* (Miller) Gaudin). These forms became the most important in western temperate areas.

Celery has also a long history in China, dating back to at least the 6th Century. The Chinese celery most resembles the leaf celery (var. *secalinum*), which is also most widespread in South-East Asia. The vernacular names in South-East Asia indicate that celery was introduced from Europe in the western parts (Dutch-derived names in Indonesia and Malaysia), and from China in the eastern parts (Chinese-derived names in the Philippines).

Uses Westerners use the leaves and petioles of stalk celery and the swollen tubers of celeriac mainly for soups and salads. Leaf celery is used as a flavouring, fresh or in dried powdered form.

In South-East Asia, leaf celery (including Chinese celery) is the most important type. It is eaten raw as well as steamed, and minced leaves are mixed through a variety of dishes.

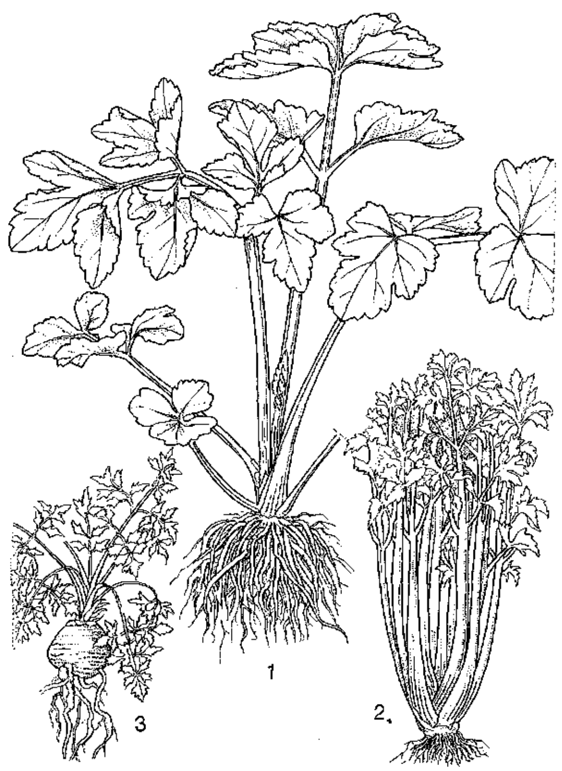
Celery is sometimes specifically grown for its seed (e.g. in India), which contains a valuable volatile oil used in the perfume industry, both as a fixative and additive. The oil is also used for flavouring salt. The plant has several applications in traditional medicine, particularly as a diuretic and emmenagogue, and against dengue and rheumatism.

Production and international trade There is a considerable production and international trade in stalk celery and celeriac among western countries. In Europe, leaf celery has been mainly replaced by parsley. In South-East Asia leaf celery is the main form, but no production statistics are available.

Properties Leaf celery has a much higher mineral content than blanched stalk celery. It contains per 100 g edible portion: water 90 g, protein 2.2 g, fat 0.6 g, carbohydrates 4.6 g, fibre 1.4 g, ash 1.7 g, vitamin A 2685 IU, vitamin B_1 0.08 mg, vitamin B_2 0.12 mg, niacin 0.6 mg, vitamin C 49 mg, Ca 326 mg, P 51 mg, Fe 15.3 mg, Na 151 mg, K 318 mg. The energy value is 113 kJ/100 g.

The plant contains the glucoside apiin and a volatile oil consisting chiefly of terpenes, but the characteristic smell seems to be due to the lactone sedanolid. The camphor of the volatile oil is known as apiol. The weight of 1000 seeds is 0.3–0.5 g.

Description Biennial, erect, copiously branched, glabrous herb, 25–90 cm tall, with a fusiform to tuberiform fleshy taproot, and rosulate leaves when young. Stem fistular, angular, strongly grooved and ribbed longitudinally. Leaves long-petioled (often only a sheath), simply pinnate or 3-foliolate; leaflets broad from a cuneate base, 2–5 cm × 1.5–3 cm, trilobate to tripartite, petiolulate. Inflorescence a compound, many-flowered umbel, sessile or short-peduncled, terminal or opposite the leaves; primary rays 5–15, 1–3 cm long; involucres and involucels absent; umbellules 6–25-flowered; flowers hermaphrodite, 5-merous, white to greenish-white; pedicel (secondary ray) 2–3 mm long; calyx teeth absent; petals 0.5 mm across. Fruit a schizocarp, splitting into 2 mericarps, each up to 1.5 mm long and with 5 light-coloured ribs.



Apium graveolens L. – 1, habit cv. group Leaf Celery; 2, habit cv. group Stalk Celery; 3, habit cv. group Celeriac.

Growth and development Celery is biennial in temperate areas, but cultivated as an annual for the vegetative parts. The life-cycle can, however, be completed in a year, if the plant is subjected to low temperatures during development.

Germination and seedling growth are rather slow and it takes 2–3 months to reach a suitable size for transplanting. During the vegetative phase, the plant above ground mainly consists of leaves, the stem being very short. The stem elongates after vernalization, the terminals ending in compound umbels. The root system is quite restricted and superficial. Crop duration depends on type (longest for celeriac), cultivar, and market preference, but varies from 4–12 months. Celery is mainly cross-pollinated.

Other botanical information It is most practical to distinguish in *Apium graveolens* 3 cultivar groups:

- cv. group Leaf Celery (var. *secalinum* Alef.): cultivated for the aromatic leaves. It has slender green petioles, and is closest to the wild form (var. *graveolens*);
- cv. group Stalk Celery (var. *dulce* (Miller) Pers.): cultivated for its strongly developed petioles, which are curved in cross-section and grooved on the external surface, with a distinct joint where the petiolules of the leaflets are attached;
- cv. group Celeriac (var. *rapaceum* (Miller) Gaudin): grown for the roundish turnip-like swelling, about 10 cm across, mainly derived from the hypocotyl, but also incorporating part of the taproot and stem.

Chinese celery most resembles leaf celery (var. *secalinum*).

Ecology The wild form of *A. graveolens* is a halophilous marsh plant and this explains the high water needs and good salt tolerance of the cultivated forms. The types of European origin are usually cultivated in the tropics at higher elevations. They are adapted to areas with monthly mean temperatures of 15–21°C. Exposure at the five-true-leaf stage to 5–10°C for a minimum of 10 days, causes bolting. However, there is seldom a problem of premature flowering in the tropics. The Chinese forms are more heat-tolerant than the European forms and can be grown in the lowlands. Both types can be planted in South-East Asia year-round.

Celery demands a moist, pervious, fertile, if possible slightly saline soil, with pH 6–6.8, well-supplied with organic matter.

Propagation and planting Celery is generally propagated by seed, leaf celery sometimes vegetatively by division. Seed is small (2000–3000 seeds per g) and is sown by broadcasting on a nursery bed. It is slow to germinate and the small and delicate seedlings should be well-protected. Transplanting to the field takes place 6–10 weeks after sowing. Leaf celery is planted relatively closely at 10–15 cm × 10–15 cm. Celeriac and stalk celery need wider spacing (30–40 cm × 30–40 cm), and the latter is planted in 20 cm deep furrows to facilitate the blanching of the petioles by earthing-up.

Husbandry Deep cultivation to a depth of 20–30 cm is recommended, in particular for celeriac (tuber development) and stalk celery (to facilitate earthing-up). It also allows the incorporation of organic matter. Large amounts of nutrients are needed for a good celery crop. The removal of nutrients in 20 t/ha of stalk celery is estimated at 75 kg N, 40 kg P_2O_5, 170 kg K_2O, 50 kg CaO and 18 kg MgO. Celery is susceptible to certain physiological disorders. These can usually be remedied by 10–20 kg/ha of borax and 100 kg/ha of magnesium sulphate.

Celery is shallow-rooting, necessitating frequent replenishment of soil moisture. Cultivation must be superficial in order to avoid damaging the roots. Thus mulching the soil surface helps retain moisture and smother weeds.

For stalk celery, the process of blanching is started 3–4 weeks before harvest by earthing-up or by wrapping paper around the petioles. White succulent petioles develop in the tropics, but they remain much smaller than in temperate areas. There are self-blanching cultivars (they have reduced pigmentation and closed plant-type and must be planted at high densities).

Diseases and pests Diseases of celery include early blight, caused by *Cercospora apii*, and late blight, caused by *Septoria apiicola*. These fungi are seedborne and can survive on plant refuse in the soil. Seed treatment and crop rotation are recommended practices. *Erwinia carotovora*, a bacterium causing soft rot of the petiole, is also soilborne, and requires crop rotation. Damping-off of seedlings caused by species of *Pythium*, *Sclerotium* and *Rhizoctonia* is common. *Rhizoctonia solani* is also reported to cause lesions and rot of the petioles.

Few specific pests have been reported on celery, apart from polyphagous insects such as aphids, spider mites, leafhoppers, whiteflies and leafminers.

Harvesting Leaf celery (including Chinese celery) can be harvested by pulling or by repeated cuts. In commercial plantings in South-East Asia, the once-over harvest is most common. The plants are pulled when 20–40 cm high, 6–10 weeks after transplanting or 3–4 months after sowing. The plants can also be cut about 6 weeks after transplanting, and subsequently harvested at regular intervals for about half a year.

Stalk celery and celeriac take from 6–12 months to become harvestable. Stalk celery is usually cut below the surface of the soil, leaving the petioles attached to the base of the stem. Tillers or suckers and pronged outer petioles are removed.

Yield Yields of about 10 t/ha have been reported for leaf celery or Chinese celery, harvested by pulling. 50 t/ha is a normal yield in Europe for leaf celery harvested by 3 successive cuts, the first after 3–4 months, the next 2 at monthly intervals.

Stalk celery has been reported to yield 25–50 t/ha in Malaysia.

Handling after harvest The harvested product should be removed from the field as soon as possible, washed, packed and transported to the market. For long-distance transport it should be packed in scraped ice. Celery can be stored for about 1 month at a temperature near 0°C at very high humidity. It should be isolated in storage, because it readily absorbs flavours from other produce. In some western countries, celery is processed by canning. In the United States, stalk celery is also dried and processed into celery salt.

Genetic resources Important germplasm collections are maintained by the Research and Plant Breeding Institute for Vegetables in Olomouc, Czech Republic, by the National Bureau of Plant Genetic Resources, New Delhi, India, by the Vavilov Institute of Plant Industry, Petersburg, Russia, by the Institute of Horticultural Research, Wellesbourne, United Kingdom, and by the Northeast Regional Plant Introduction Station, Geneva, New York, United States.

Breeding Breeding programmes are mainly aimed at improving stalk celery and celeriac, two types of minor importance in the tropics. In stalk celery, the major objectives concern the tenderness of the petioles, the self-blanching character of cultivars and disease resistance. Little systematic research is being done on leaf celery.

Prospects Leaf celery is an important commercial vegetable crop in South-East Asia and an important ingredient in South-East Asian cuisine. Stalk celery should not be promoted at the expense of leaf celery, because the latter has a shorter growing season, is easier to grow and has higher nutritional value.

Literature |1| Buwalda, P., 1949. Umbelliferae. In: van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 4. Noordhoff-Kolff, Djakarta, Indonesia. pp. 113–141. |2| Fritz, D., Stolz, W., Venter, F., Weichmann, J. & Wonneberger, C., 1989. Gemüsebau [Vegetable growing]. 9th revised edition. Ulmer, Stuttgart, Germany. pp. 191–197. |3| Knott, J.E. & Deanon Jr, J.R. (Editors), 1967. Vegetable production in South-East Asia. University of the Philippines Press, Los Baños, the Philippines. pp. 318–329. |4| Yamaguchi, M., 1983. World vegetables: principles, production and nutritive values. Avi Publishing Company, Westport, Connecticut, United States. pp. 246–248.

S. Susiarti & J.S. Siemonsma

Archidendron jiringa (Jack) Nielsen

Adansonia, ser. 2, 19: 32 (1979).
LEGUMINOSAE
$2n = 26$ (?)

Synonyms *Pithecellobium lobatum* Benth. (1844), *P. jiringa* (Jack) Prain (1897), *Zygia jiringa* (Jack) Kosterm. (1954).

Vernacular names Indonesia: jengkol, jering, jingkol, jringkol. Malaysia: jiring. Burma: tangyin, tanyeng-pen. Thailand: niang (peninsular), niang-nok (peninsular), chaniang (eastern).

Origin and geographic distribution *A. jiringa* is of South-East Asian origin and occurs wild and cultivated in Malaysia, Indonesia (Java, Sumatra, Kalimantan), Brunei, Thailand, Burma and Bangladesh.

Uses The seeds of jengkol are mainly used to add flavour to food, and are relished by Indonesians and Malaysians. To some people, however, their smell is rather offensive. Young seeds are often eaten raw. Mature seeds are prepared in several ways: 1) boiled thoroughly till the offensive smell has disappeared, and consumed with salt and grated coconut, 2) steeped for a couple of hours in salt water, before being fried in oil; this also removes most of the bad smell, 3) processed into chips ('emping' or 'kripik jengkol'); after cooking, the cotyledons are flattened by hammering them into the shape of small cakes which are sundried, and fried in oil before consumption, 4) buried for 14 days until they germinate, then dug up and washed clean, whilst at the same time the sprouts are cut off and thrown away ('sepi'). The latter way of preparation is said to minimize the danger of intoxication by jengkolic acid, crystals of which can cause kidney failure. It is recommended to drink much water when eating the seeds. The very young wine-red shoots are also consumed raw as vegetable.

The pods were used as a source of purple dye for silk in the past; they are still used as a shampoo. In Kalimantan, the bark is used for dyeing matting black; to obtain this colour the mat is boiled with extract from the bark and then immersed in mud.

The old leaves, burnt to ashes, are used against itching. The ashes of young leaves are used as wound powder for cuts (e.g. circumcision).

The timber is soft, easy to saw and to work with; therefore it is only suitable for cabinet work, interior joinery or as firewood.

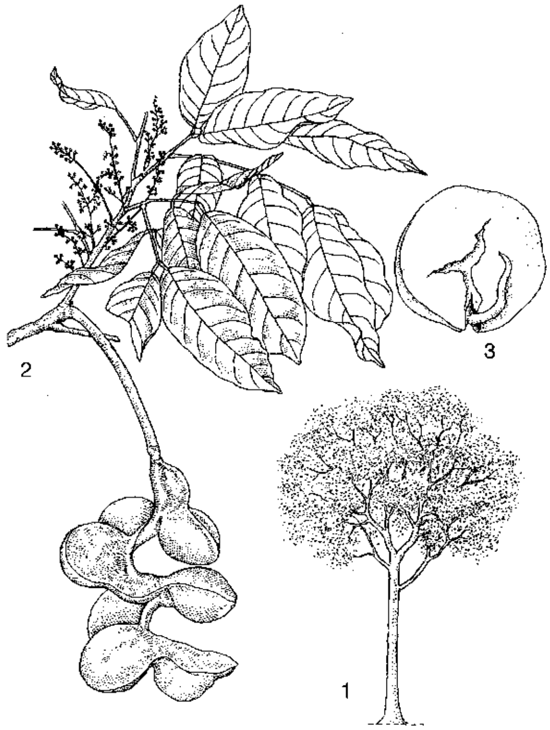
Production and international trade In its area of distribution, jengkol is a popular food and local production is considerable; however, no statistics are available. Fruits (containing the seeds) are traded on local markets only.

Properties Per 100 g edible portion, young immature seeds contain: water 93 g, protein 3.5 g, fat 0.1 g, carbohydrates 1.7 g, Ca 21 mg, P 25 mg, Fe 0.7 mg, vitamin A 240 IU, vitamin B 0.1 mg, vitamin C 12 mg. The energy value is 92 kJ/100 g. Ripe seeds consist for about 70% of starch. Jengkol has a good amino-acid profile, and is rich in cysteine.

The seeds contain a volatile oil consisting of an allyl sulphur compound, and an alkaloid, which act as diuretic. They also contain 1.3–1.8% or an average of 225 mg/seed of the toxin jengkolic acid ($C_7H_{14}O_4N_2S_2$). Excessive consumption may lead to the 'kejengkolan' disease, caused by crystallization of jenkolic acid in the kidneys and bladder, with the following symptoms: renal hyperemia, oliguria to no urination at all, and pain when urinating.

Seed weight is approximately 15 g per seed.

Botany Tree, up to 20 m tall with grey smooth bark, white wood and terete, glabrous branchlets. Leaves 2-pinnate, up to 25 cm long; petiole 2–6 cm long; leaflets 2–3 pairs per pinna, ovate-elliptical to oblong, 8–15 cm × 4–5 cm, opposite, chartaceous, glabrous, dark violet-red when young. Inflorescence axillary, paniculate, up to 20 cm long; flowers sessile, 4–7 together in a pseudo-umbel on a short peduncle, 5-merous, bisexual; calyx cup-shaped; corolla tubular, 4–5 mm long, 5-lobed, white; stamens numerous, at base united into a tube, free filament parts ca. 5 mm long. Fruit a legume, compressed, falcate or twisted in a wide spiral, more or less deeply lobed along the ventral



Archidendron jiringa (Jack) Nielsen – 1, habit; 2, flowering and fruiting shoot; 3, germinating seed.

suture between the seeds, 20–25 cm × 3–4 cm, woody, greyish, glabrous, dehiscent along the ventral suture. Seeds compressed orbicular, ca. 35 mm × 10 mm, testa yellow-green when young, turning dark brown. Germination is hypogeal and the first five leaves are scale-shaped.

A. jiringa starts bearing 5–6 years or more after sowing. Flowers open in the evening after dark and pollination is effected by moths and other insects. Flowering and fruiting are year-round, but peak periods occur. It takes 40–50 days from anthesis to mature fruits.

There are a few forms differing in size and tenderness of the seeds. They are sometimes distinguished in Indonesia as 'jingkol' or 'jengkol gobang' with large, somewhat hard and slightly bitter seeds, and 'jringkol' with smaller, more tender and less bitter seeds.

Several other *Archidendron* species in South-East Asia also produce edible seeds (e.g. *A. bubalinum* (Jack) Nielsen, *A. quocense* (Pierre) Nielsen, *A. microcarpum* (Benth.) Nielsen, but they seem more poisonous. Only *A. jiringa* is purposely cultivated in fields, around villages and in home gardens.

Ecology *A. jiringa* occurs in primary and secondary rain forest and in evergreen forest. Trees are often spared when the forest is cut down. It prefers a pervious soil and high rainfall. It is recorded from sandy soil, lateritic soil, reddish sandy clay, flat land and low undulating hills, from sea-level up to 1000(–1600) m altitude.

Agronomy Jengkol is propagated by seed. Squirrels (*Callosciurus notatus*) eat the seeds and facilitate its distribution. In cultivation, planting distances are 10–15 m. Jengkol has a number of pests in common with other leguminous trees and shrubs such as the pod-borers *Mussidia pectinicornella* and *Cryptophlebia ombrodelta*, and the caterpillars of the leaf-feeder *Eurema blanda*, one of the most common butterflies in Java.

A mature tree produces from 1000–4000 seeds/year. The main harvest period in Java is in July – August, the after-crop in December – February. Jengkol is sold in the market by number of seeds. For transport, seeds, in particular young ones, should not be removed from the pods to avoid desiccation. Processed into chips, they can be stored for a long period.

Prospects *A. jiringa* will remain an important relish. Very little information has been gathered on this tree in recent times. More research might be rewarding, in particular on methods to reduce the danger of intoxication, to control insect pests without spraying pesticides and on methods for clonal propagation.

Literature |1| Kartawinata, K. & Sastrapradja, S. (Editors), 1979. Kayu Indonesia [Indonesian timbers]. LBN-LIPI 14. Project of Indonesian Economic Plant Resources No 55. LBN-LIPI, Bogor, Indonesia. p. 37. |2| Nielsen, I.C., 1985. Leguminosae – Mimosoideae. In: Smitinand, T. & Larsen, K. (Editors): Flora of Thailand. Vol. 4(2). The Forest Herbarium, Royal Forest Department, Bangkok, Thailand. pp. 217–219. |3| Soeparma Satiadiredja, 1950. De teelt en het gebruik van Indonesische groenten en toekruiden [The cultivation and use of Indonesian vegetables and condiments]. Wolters, Groningen, the Netherlands. p. 67. |4| Suhaila Mohamed, Mohamed Shamsuddin Abd. Rahman, Sabturiah Sulaiman & Fauziah Abdullah, 1987. Some nutritional and anti-nutritional components in jering (Pithecellobium jeringa), keredas (Pithecellobium microcarpum) and petai (Parkia speciosa). Pertanika 10(1): 61–68.

H. Wiriadinata

Asparagus officinalis L.

Sp. pl.: 313 (1753).
LILIACEAE
$2n = 20$

Vernacular names Asparagus (En). Asperge (Fr). Indonesia/Malaysia: asparagus. Philippines: asparago (Tagalog). Cambodia: tum'-peang barang. Thailand: nomai-farang. Vietnam: m[aw]ng t[aa]y.

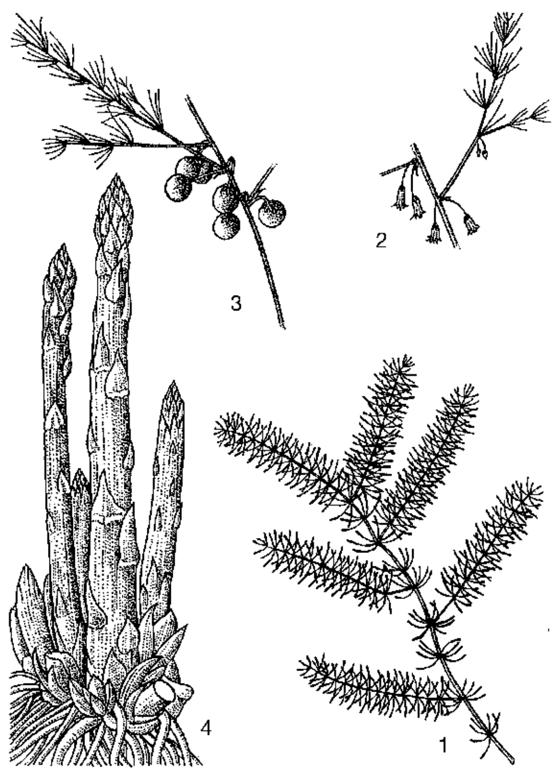
Origin and geographic distribution The origin of asparagus is believed to be the eastern Mediterranean; however, it grows wild in Europe, the Caucasus and western Siberia. It is also naturalized in the Americas and New Zealand, and occurs now worldwide as a crop plant. In South-East Asia it is found mainly in Indonesia, Malaysia, and Thailand.

Uses The major use of asparagus is to eat the lightly cooked tender young unexpanded shoots (spears). The spears are also processed either by quick-freezing, or by canning (or bottling) in brine. Spears may be harvested prior to emergence as white asparagus, or after emergence when 18–25 cm tall as green asparagus. The green spears should be all green, while the white spears should be all white. It is normal to peel the white spears prior to cooking, while the green spears are normally eaten unpeeled. There are references to the seed being used as a coffee substitute.

Production and international trade It is estimated that there are about 150 000 ha of asparagus grown worldwide, producing some 500 000 t/year. Production predominates in North America (52 000 ha) and Europe (45 000 ha), with South America (3000 ha) and Asia (20 000 ha) increasing in importance. Australasia (6000 ha) and Africa (3000 ha) are relatively unimportant. The world price fluctuates tremendously, but tends to be about 1000 US$/t. In the South-East Asian region asparagus is gaining in importance, with production predominating in Thailand and Indonesia, followed by Malaysia. Current statistics (1990) are: Thailand (1804 ha) producing 7966 t (85% green, 15% white; 85% is consumed locally, and in 1989 there were 900 t of fresh export and 186 t of canned export); Indonesia (1000 ha) producing 2100 t (60% green, 40% white; in 1990 80% was consumed locally, and there were 105 t of fresh export and 315 t of canned export). No data are available for the other countries, but Malaysia has much less production than either Indonesia or Thailand. There are plantings in the Philippines, chiefly in Mindanao.

Properties The composition of the edible spears depends on whether one is considering white or green asparagus. Green asparagus contains per 100 g fresh weight: water 92 g, protein 2.8 g, fat 0.2 g, carbohydrates 2.2 g, vitamin A 980 IU, vitamin B_1 0.23 mg, vitamin B_2 0.15 mg, niacin 2.2 mg, C 48 mg, Ca 24 mg, Fe 1.5 mg, P 52 mg. The energy value is 113 kJ/100 g. White asparagus is slightly lower in protein (2.1 g), and considerably lower in some of the vitamins and minerals (vitamin A 50 IU, vitamin B_2 0.08 mg, niacin 1.1 mg, C 28 mg, Ca 16 mg). The average weight of 1000 seeds is 40 g.

Description Herbaceous, dioecious, climbing or erect perennial, up to 2 m tall, with a robust woody rhizome comprising a number of bud clusters and many long (1.5–2 m) unbranched, fleshy storage roots. Young stem fleshy when still underground; aboveground stem strongly branched, with fine, needle-like foliage. True leaves reduced to minute bract-like triangular brownish scales; in the axils of the scales, 3–6 subterete, green, needle-like, thin branchlets (cladodes), 1–2 cm long



Asparagus officinalis L. – 1, leafy shoot; 2, flowering shoot; 3, fruiting shoot; 4, crown with spears.

are present and seem to represent the leaves. Flowers solitary or in pairs in the leaf-axils, unisexual, small, tubular-campanulate, pendulous; tepals 6–8 mm long in male, 4–6 mm in female flowers. Fruit a globose berry, red, 1–6-seeded. Seed black.

Growth and development Germination is normally slow, with the optimum temperature being 25–30°C. Initially a single shoot, and a single root develop, but once the first shoot has fully expanded, a second shoot develops from the junction of the initial shoot and the root. This is the origin of the primary bud cluster, but in time secondary bud clusters develop in the axils of some of the primary buds. It is normal for each bud to develop two storage roots at about the time the bud develops into a shoot. There is very strong apical dominance on each bud cluster, and the next bud on the cluster does not normally develop until the previous bud is fully developed into a shoot (or the spear is harvested). In the tropics the foliage remains green and the plant never goes dormant. In temperate climates the aerial parts senesce during autumn, and growth is continued the following spring by the shooting of buds from the rhizome. Because the spears from these buds comprise the marketable yield, it is necessary initially to establish a large pool of stored food reserves in the swollen roots before harvesting, so that it is general practice not to harvest until 2 years after planting, and from the third to the fifth year slowly to increase the harvest period from 3–4 weeks to 10–12 weeks. It seems that senescence of asparagus in the tropics starts earlier than in temperate areas due to the absence of dormancy. In western Europe, plants of over 100 years of age have been reported, although it is normally not economical to harvest longer than ca. 10 years. In the tropics the crop is mostly used up after 5–6 years.

Other botanical information Asparagus is normally dioecious, but occasionally andromonoecious plants occur. The plants are insect-pollinated. Many wild *Asparagus* L. species exist, mainly in Europe, Africa and Asia. In South-East Asia, *A. cochinchinensis* (Lour.) Merrill (distributed from Indo-China to Japan and the Philippines) produces edible tubers and *A. racemosus* Willd. (distributed from Africa through southern Asia and Malesia to Australia) edible roots. In Europe, many cultivars of *A. officinalis* exist.

Ecology Asparagus does not appear to have a daylength response. Photosynthetic activity appears to increase up to 300 W/m^2 PAR (Physiologically-Active Radiation) as in most C_3 plants. The optimum temperature for dry matter accumulation is 25–30°C, but the optimum temperature for the accumulation of food reserves in the roots may be slightly lower. High relative humidity is a distinct disadvantage due to the problems of foliage diseases. The crop can be successfully produced at low altitudes even in the tropics, though spear quality may not be as high as that produced at higher altitudes. Absence of frost during the growing season is important. Deep well-drained sandy loams or volcanic soils are preferable, with an adequate supply of nutrients, particularly nitrogen and potassium. Asparagus appears to be able to grow in a very wide range of pH, though 5.8–6.5 appears optimum.

Propagation and planting Propagation is primarily by seed. There is increasing interest in vegetative propagation (using tissue culture methods) to clone up high quality plants, but this method is still in the experimental stage. Seed may be sown either directly in the final growing site (uncommon), or in the field in a seedling nursery, or in modules under protective cultivation (increasingly important with the higher costs of seed). Because the crop is long-term, the choice of cultivar is critical. Plant spacing is normally 1.50 m × 0.30 m.

Husbandry Good control of weeds is essential, not only to reduce competition, but also to enable the young spears to be seen at harvest. Staking is sometimes done in the tropics when using the 'mother fern' system (see under Harvesting). The only pruning might be to remove the tops of shoots in the tropics to reduce damage by wind. Irrigation requirements will depend on rainfall, but because the crop is deep-rooted it is not normally considered important except in arid areas.

Diseases and pests In the humid tropics the major diseases are those attacking the foliage, namely *Stemphylium botryosum*, *Cercospora asparagi* and *Phoma asparagi*. Control is by regular spraying with fungicides (e.g. Mancozeb). Some cultivars developed in New Jersey (United States) appear to have some resistance to these diseases. *Fusarium* species are a major problem in all climates, and appear to be stress-related due to excessive harvesting. *Fusarium* as well as *Phoma* can also be kept under control with good drainage and a balanced fertilizer application.

Harvesting In temperate climates the young spears are harvested in spring for up to 12 weeks, and the foliage is then allowed to grow to replenish the stored reserves in the roots for next year's crop. In tropical climates, harvesting is usually at any time of the year, using a 'mother fern' growing system, in which (once a plant is well established) any newly developed spears are harvested at the appropriate stage, while at the same time maintaining 3–5 mature photosynthesizing shoots. For green asparagus, spears are cut at (or just below) ground level with a knife when they are about 18–25 cm tall. For white asparagus the spears are cut 10 cm above the rhizome just before the spears emerge through the soil surface.

Yield Worldwide the average yield is 3 t/ha per year, but because of the long period of establishment, yields from established crops are 20% higher. In South-East Asia, although the yield potential is probably higher, the actual yields average only 2.1 t/ha per year in Indonesia, and 4.4 t/ha per year in Thailand, although these should be increased for established crops by about 40% to account for plantings which have not yet come into production.

Handling after harvest Asparagus spears have a high respiration rate and therefore deteriorate very rapidly after harvest. They should be removed from the field as soon as possible after harvest and then stored at high humidity and 2°C (for up to 4 weeks).

Genetic resources Important germplasm collections of *A. officinalis* cultivars are held at the Crops and Food Central Research Institute, Lincoln, Canterbury, New Zealand, and by USDA, United States.

Breeding The major breeding objectives are related to the development of improved cultivars for disease resistance, and for improved yield and quality. Appearance and low fibre content are particularly important in white asparagus. In Europe, breeding efforts are directed towards the production of male hybrid cultivars with big spears of uniform quality. Male plants live longer and yield better than female plants.

Prospects There is increasing interest from affluent countries in obtaining fresh asparagus year-round. This asparagus is obtained from northern and southern hemisphere sources during the appropriate spring periods, but could be supplied from the tropics during the remaining 6 months of the year. With the increasing interest in fresh rather than processed vegetables, the potential for this crop in the tropics appears excellent, particularly when related to the low labour costs in many tropical countries. The major challenge is to develop cultivars which are better adapted to the tropics, and the appropriate technology for production in the humid tropics through the correct choice of site (high, medium, or low altitude) and harvesting strategy. Other priorities are the control of foliage diseases and the establishment of sound post-harvest and transportation infrastructures.

Literature |1| Hung, Lih, 1980. Special aspects of growing asparagus in Taiwan. Journal Chinese Society for Horticultural Science 26(1): 1–10. |**2**| Nichols, M.A., 1990. Asparagus – the world scene. Acta Horticulturae 271: 25–31. |**3**| Nichols, M.A., 1991. Asparagus production in the tropics. Acta Horticulturae (in press). |**4**| Robb, A.R., 1984. Physiology of asparagus (Asparagus officinalis) as related to the production of the crop. New Zealand Journal of Experimental Agriculture 12: 251–260.

M.A. Nichols

Basella alba L.

Sp. pl.: 272 (1753).

BASELLACEAE

$2n = 44, 48$

Synonyms *Basella rubra* L. (1753), *B. lucida* L. (1759), *B. cordifolia* Lamk (1783).

Vernacular names Ceylon spinach, Indian spinach, Malabar nightshade (En). Baselle, brède de Malabar (Fr). Indonesia: gandola, genjerot. Malaysia: gendola, remayong, tembayung. Philippines: alugbati, dundula, libato. Cambodia: chrâlong. Laos: pang. Thailand: phakpang (northern), phakplang, phakplang-yai (central). Vietnam: m[oof]ng t[ow]i, m[uf]ng t[ow]i.

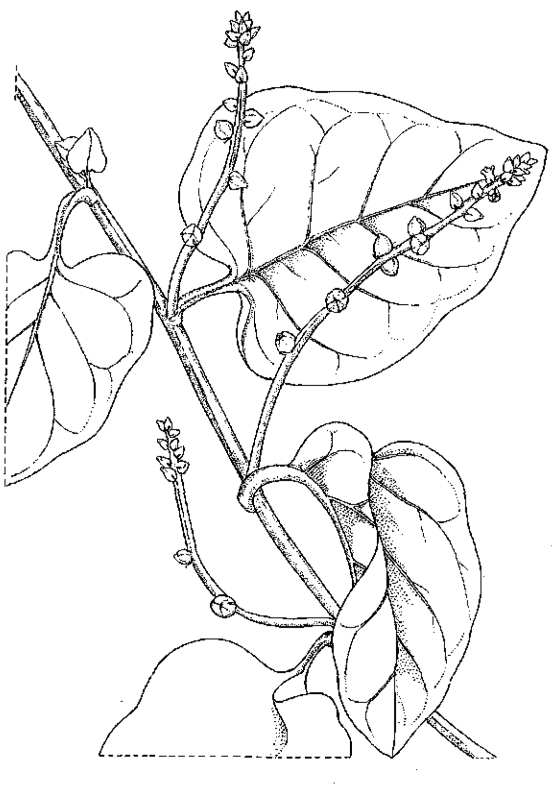
Origin and geographic distribution Ceylon spinach is usually considered native of southern Asia (India), but its exact origin is not known. In South-East Asia and China it has been grown since ancient times. It is now widely cultivated in tropical Asia, Africa and America, and is even grown in temperate zones as an annual. In South-East Asia it is particularly popular in Malaysia and the Philippines.

Uses Ceylon spinach is commonly grown for its young shoots which make an excellent succulent, slightly mucilaginous vegetable, used as a pot herb in stews or soups, consumed boiled, fried in oil, or sometimes as a green salad. An early use of its fruits in China seems to have been for dyeing purposes. The red fruit juice can be used as ink and cosmetic, and for colouring foods. A number of medicinal applications have been reported: young leaves as a laxative, pulped leaves to poultice sores, red fruit juice as eye-drops to treat conjunctivitis, and in the Philippines the roots are employed as a rubefacient. The red forms are commonly planted as ornamentals, even becoming popular in Europe as a pot plant.

Production and international trade Ceylon spinach is a small-scale vegetable and since it is generally grouped together with other greens, no individual production data are available.

Properties Shoots of Ceylon spinach contain per 100 g edible portion: water 91 g, protein 2.1 g, fat 0.3 g, carbohydrates 3.9 g, fibre 1.3 g. The energy value is approximately 112 kJ/100 g. The protein content is relatively low compared to other greens. The vitamin and mineral contents vary widely: vitamin A 1686–6390 IU, vitamin C 29–166 mg, Ca 16–117 mg, Fe 1.2–3.1 mg per 100 g edible portion. 1000-seed weight is 30–40 g.

Botany Short-lived perennial herb, 2–6 m long, succulent; stem twining, slender, smooth, green or purplish. Leaves alternate, ovate to heart-shaped with short fleshy petiole, 5–15 cm × 4–10 cm, fleshy, dark green or purplish. Inflorescence a spike, hanging, axillary, 3–21 cm long; flowers inconspicuous, bisexual, sessile, 3–4 mm long, white, pink or purple; ovary rounded, styles 3, united at the base, stamens 5. Fruit a depressed-globose pseudo-berry, 4–7 mm × 5–10 mm, purplish-black, with fleshy perianth which encloses the ovary after flowering, and containing a violet juice. Seed single.



Basella alba L. – flowering and fruiting shoot.

Three main types, which are sometimes considered distinct species, can be distinguished, The most common one has dark green, ovate or nearly round leaves. A less popular type, often planted as ornamental, has red ovate or nearly round leaves and red stems (synonym *B. rubra*). The third has heart-shaped, dark green leaves (synonym *B. cordifolia*).

B. alba is a perennial; it sends out runners over the soil and develops new roots at the nodes, thus growing on indefinitely. If grown as a climber on trellises it usually tends to die back after 2 or more years when not well cared for. With proper fertilizer application, hedges of Ceylon spinach may be maintained for long periods. In subtropical and temperate regions, new plantings must be made each year.

Ecology Ceylon spinach does well in tropical lowlands at elevations up to 500 m, but it survives even at 3000 m altitude and in temperate regions. It is a short-day plant, flowering being precluded at a daylength of more than 13 hours. It has a C_4-cycle photosynthetic pathway similar to that of amaranth. Water stress promotes early flowering. *B. alba* is tolerant of many soils, but sandy loam appears to be most suitable.

Agronomy Ceylon spinach is an easy-growing plant propagated by seed or by cuttings. Fresh healthy tip cuttings of about 20–25 cm length are the best planting material. In home gardens it is usually grown on slanting or horizontal trellises, but in market gardens often without support. For commercial production, densities of about 50 000 plants/ha are recommended.

B. alba can thrive under conditions of moderate fertility, but is quite responsive to nitrogen. The first harvest of young shoots is about 6–8 weeks after planting, subsequently at regular intervals for 4–6 months until flowering interferes too much with quality. Shoots 15–25 cm long are cut, bunched and sold at nearby markets. If undamaged, leaves can be kept for about one week in the refrigerator. Commercially grown crops may yield approximately 50 t/ha per year. Approximately 1000 kg seed per ha can be obtained annually.

B. alba is very susceptible to root knot nematodes, but is distinctly free of disease and pest problems due to its very thick leaf cuticle. Leaf-spots caused by *Cercospora* and *Acrothecium* sometimes occur.

Genetic resources and breeding No germplasm collections are known and there are no breeding programmes. There seems to be no immediate danger of genetic erosion, but collection and screening of local types is advisable. Catalogues of Indian seed companies offer seeds of *B. alba* for sale.

Prospects Ceylon spinach is a very productive leaf vegetable, suitable for both home and market gardens in the lowland tropics. An important advantage of this leafy vegetable is its remarkable resistance to diseases and pests.

Literature |1| Evensen, S.K. & Standal, B.R., 1984. Use of tropical vegetables to improve diets in the Pacific region. Research series 028, College of Tropical Agriculture and Human Resources, University of Hawaii. 32 pp. |2| Grubben, G.J.H., 1977. Tropical vegetables and their genetic resources. Tindall, H.D. & Williams, J.T. (Editors). International Board for Plant Genetic Resources (IBPGR), Rome, Italy. pp. 97–101. |3| Martin, F.W. & Ruberté, R.M., 1975. Edible leaves of the tropics. Antillian College Press, Mayaguez, Puerto Rico, United States. pp. 23–24. |4| van Steenis, C.G.G.J., 1957. Basella. In: van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 5. Noordhoff-Kolff, Djakarta, Indonesia. Vol. 5. pp. 300–302. |5| Winters, H.F., 1963. Ceylon spinach (Basella rubra). Economic Botany 17(3): 195–199.

M. Rahmansyah

Benincasa hispida (Thunberg ex Murray) Cogniaux

In: A. DC, Monogr. phan. 3: 513 (1881).

CUCURBITACEAE

$2n = 24$

Synonyms *Cucurbita hispida* Thunberg ex Murray (1784), *Benincasa cerifera* Savi (1818).

Vernacular names Wax gourd, white gourd, Chinese preserving melon (En). Courge à la cire, courge cireuse (Fr). Indonesia: kundur, bligo, kundo (Aceh). Malaysia: kundor. Philippines: kondol (Tagalog), tibiayon (Bisaya), rodal (Bicol). Cambodia: trâllaach. Laos: tônx. Thailand: fak, faeng (central), mafaeng (northern). Vietnam: b[is] dao, b[is] xanh.

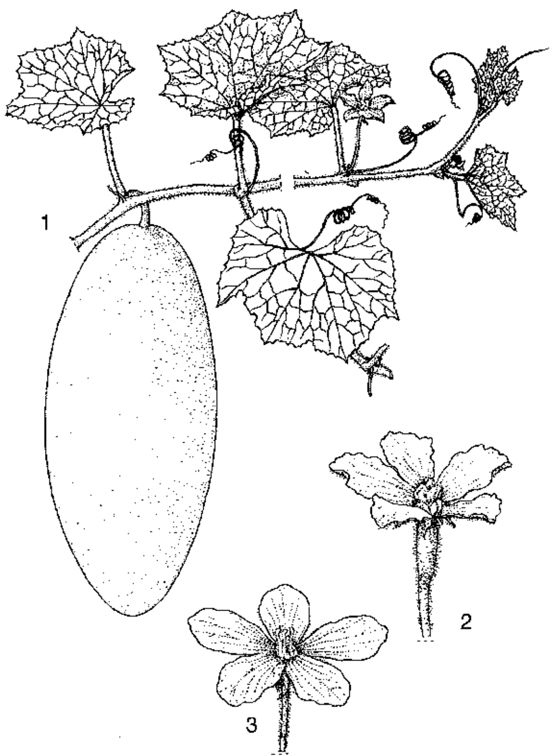
Origin and geographic distribution The genus *Benincasa* Savi is usually considered monotypic. There is no general agreement on the origin of the wax gourd. Indo-China and India are the centres of greatest diversity, but wax gourd is not known from the wild and no related wild species are known. There is some evidence that *B. hispida* has been cultivated in China since 500 AD. The wax gourd is now widely cultivated throughout tropical Asia, and has been introduced to other tropical, subtropical and warm temperate parts of the world as well (e.g. the Caribbean).

Uses Wax gourd is cultivated for its immature as well as mature fruits. People in Indonesia normally scrape the skin off the gourd, discard the seeds and pith, and chop the greenish-white flesh into small blocks to be cooked in various kinds of soups. The Chinese cook wax gourd in various ways, including stuffing the entire gourd with chopped meats, shrimps, lotus seeds, mushrooms and bamboo shoots, and then steaming it in a pot. The firm flesh is often cut into pieces and candied with sugar, yielding the well-known 'tangkwè'. The flesh can also be dried for later use. In India the young fruits are extensively used in curries. Young shoots, leaves and flowers are also used as a vegetable. The seeds are often consumed after frying as a snack food; they are considered vermifugal as well. The Madurese (Indonesia) are known to use young wax gourd leaves as wrappers in preparing broiled salted fish to influence the flavour and the appearance of the dish. The waxy coat of the fruits is sometimes used to make candles. The fruits are valued for their medicinal (diuretic, laxative, tonic) and cooling properties and for their beneficial effect in treating nervous disorders.

Production and international trade Wax gourd is grown throughout South-East Asia for local consumption, but seldom on a large scale. In local markets, however, it is a rather highly commercialized vegetable due to the long storage life of the mature fruits.

Properties Like most other cucurbitaceous vegetables, wax gourd is not very high in food value. It contains little vitamin A because the flesh is white. The edible portion of mature fruits is about 75%. Per 100 g edible portion, it contains: water 96 g, protein 0.2 g, fat 0.1 g, carbohydrates 3.5 g, traces of vitamin A, vitamin B_1 0.02 mg, vitamin B_2 0.03 mg, niacin 0.5 mg, vitamin C 14 mg, Ca 14 mg, Fe 0.4 mg, Mg 16 mg, P 7 mg. The energy value is 63 kJ/100 g. The seeds yield a pale yellow oil. The 1000-seed weight is approximately 70 g.

Description Robust, annual, usually monoecious, hispid, climbing herb up to several m long. Stem thick, terete, longitudinally furrowed, whitish-green with scattered rough hairs; tendrils inserted beside the leaves, 2–3-fid, 10–35 cm long, spirally coiled at the top, the two lateral arms much shorter than the central one. Leaves simple, distichous; petiole 5–20 cm long; leaf-blade broadly ovate in outline, 10–25 cm × 10–20 cm, deeply cordate at base, apex acuminate, margin more or less deeply and irregularly 5–11-angular or -lobed and irregularly undulate-crenate or dentate-serrate, densely patently hispid on both sides, shiny-green. Flowers solitary in leaf axils, large, 6–12 cm in diameter, yellow, unisexual, 5-merous; pedicel densely hispid, 5–15 cm long in male flowers, 2–4 cm in female ones; calyx campanulate, densely silky; petals almost free; male flowers with 5 stamens, 4 of these in connate pairs; female flowers with densely villose ovoid or cylindrical ovary and a short style with 3 curved stigmas. Fruit a large, stalked berry (pepo), ovoid-oblong, ellipsoid or globose, 20–60(–200) cm × 10–25 cm, dark green to speckled light green or glaucous, thinly hispid or subglabrous, covered with a chalk-white, easily removable layer of wax; flesh 2–4 cm thick, white, succulent, slightly fragrant, spongy in the middle.



Benincasa hispida (Thunberg ex Murray) Cogniaux – 1, flowering and fruiting shoot; 2, female flower; 3, male flower.

Seeds numerous, flat, ovate-elliptic, 10–15 mm × 5–7 mm × 1–2 mm, yellow-brown, sometimes prominently ridged.

Growth and development Germination is usually completed within 1–2 weeks. Wax gourd is a vigorous grower but needs a long growing season of 4–5 months. Flowering starts about 50–80 days after planting. Flowers are insect-pollinated. The fruits need 1–2 months from anthesis until full maturity. Harvest of young fruits prolongs crop duration.

Other botanical information Numerous local forms are distinguished, mainly differing from each other in fruit shape. Four groups have been proposed based on vegetative and fruit characters, but the differences seem rather small for the status of cv. groups:

- Unridged Winter Melon: seed with unridged margins; fruit cylindrical, up to 2 m long, maturing 3 months after pollination; rind dark green, almost waxless;
- Ridged Winter Melon: seed with ridged margins; otherwise very similar to the first group;
- Fuzzy Gourd: seed with ridged margins; fruit cylindrical, 20–25 cm long maturing within 2 months after pollination; rind green, almost waxless, covered with white soft hairs;
- Wax Gourd: seed with ridged margins; fruit globose to oblongoid, 10–60 cm long or in diameter, maturing within 2 months after pollination; rind light green, covered with a white waxy bloom, glabrous or finely hairy.

Cultivars are offered by seed companies in India, Thailand, Taiwan, China, Japan and the United States.

Ecology Wax gourd is best suited to the moderately dry areas of the lowland tropics. It is relatively drought-tolerant. It is grown in South-East Asia from sea-level up to 1000 m altitude. High soil temperatures are required for optimum seed germination. The optimum temperature for growth is 23–28°C. The ratio of female to male flowers is increased by relatively cool weather and short days.

Propagation and planting Wax gourd is propagated by seed. Direct-seeding in well-prepared trenches or planting holes filled with manure or compost is usually practised. When supported, plants should be spaced 60–80 cm in the row, with the rows spaced 1–1.5 m apart. For trailing over the ground, spacing must be wider (2–3 m between plants).

Husbandry Wax gourd is commonly found in home gardens where it is grown on trellises or trained over the roof, fence or onto a tree. It is also cultivated as a cash crop in the field without support. It is adapted to a wide range of soils, but prefers well-drained light soils. A high organic matter content is necessary. NPK fertilizer should be applied before sowing, and a nitrogenous fertilizer side-dressed at regular intervals until flowering.

Techniques to regulate the growth and fruiting behaviour of cucurbits are the removal of growing points, fruit thinning, and assisted pollination, but there is little detailed information on the needs of wax gourd. However, it is known that removing the growing point on young plants after the appearance of about 4 leaves, allowing 4 laterals to develop, has proved successful in greenhouse production in temperate areas. Fruits on trailing plants are often protected from soil moisture by putting them on a little straw.

Diseases and pests Wax gourd is a hardy crop and is rather tolerant to diseases such as downy mildew (*Pseudoperonospora cubensis*) during the dry season, and powdery mildew (*Erysiphe cichoracearum* and *Sphaerotheca fuliginea*) during the wet season. However, considerable damage may be incurred under high disease pressure, especially if the crop is left unmanaged.

Among the insect pests are squash beetle (*Aulacophora foveicollis*), aphids (*Aphis gossypii*) and fruit flies (*Dacus* spp.); usually these are controlled by chemical sprays.

Harvesting Immature fruits can be harvested about a week after anthesis or later, depending on the required size. Mature fruits are harvested from 100–160 days after sowing.

Yield Individual fruits can weigh between 1–45 kg. Yields up to 20 t/ha have been reported from northern India.

Handling after harvest Young fruits must be used as soon as possible because they do not store well. Mature fruits can be stored for a long period due to the waxy layer which protects them from attack by micro-organisms. Ideal storage conditions are at temperatures of 13–15°C in a fairly dry atmosphere.

Genetic resources Small germplasm collections of wax gourd are available at horticultural institutes in South-East Asia (Institute of Plant Breeding, the Philippines), India (Kerala Agricultural University), Russia (Vavilov Institute of Plant Industry, Petersburg) and the United States (Southern Regional Plant Introduction Station, Georgia; Cornell University, New York). There seems to be no danger of large-scale genetic erosion.

Breeding Some selection work on local forms has been done in India, Thailand, Taiwan, China, Japan and the United States, where wax gourd is offered in seed catalogues.

Prospects Wax gourd is still a small-scale vegetable crop in South-East Asia. Attractive characteristics are the long shelf life of the mature fruits and its resistance to diseases and pests. A disadvantage is the relatively bland taste. Some research seems justified to extend its use; dissemination of information and commercial seed sources could be improved. The potential of wax gourd as a rootstock for grafting other high-priced cucurbits deserves consideration.

Literature |1| Engel, J., 1975. Underexploited tropical plants with promising economic value. National Academy of Sciences, Washington, D.C., United States. pp. 53–55. |**2**| Esquinas-Alcazar, J.T. & Gulick, P.J., 1983. Genetic resources of Cucurbitaceae. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 101 pp. |**3**| Keraudren-Aymonin, M., 1975. Benincasa Savi. In: Flore du Cambodge, du Laos et du Vietnam [Flora of Cambodia, Laos and Vietnam]. Vol. 15. Cucurbitacées. Muséum National d'Histoire Naturelle, Laboratoire de Phanérogamie, Paris, France. pp. 44–46, 95. |**4**| Larkcom, J., 1991. Oriental vegetables. The complete guide for garden and kitchen. John Murray, London, United Kingdom. pp. 83–85. |**5**| Morton, J.F., 1971. The wax gourd, a year-round Florida vegetable with unusual keeping quality. Proceedings of the Florida State Horticultural Society 84: 104–109. |**6**| Walters, T.W. & Decker-Walters, D.S., 1989. Systematic re-evaluation of Benincasa hispida (Cucurbitaceae). Notes on economic plants. Economic Botany 43(2): 274–278.

M.A. Rifai & M.E.C. Reyes

Beta vulgaris L.

Sp. pl.: 222 (1753).
CHENOPODIACEAE
$2n = 18$

Major taxa and synonyms

- Cv. group Garden Beet: *B. vulgaris* L. convar. *crassa* (Alef.) Helm provar. *conditiva* (Alef.) Helm (1957), *B. vulgaris* L. ssp. *vulgaris* convar. *vulgaris* var. *vulgaris* sensu Mansfeld (1986), *B. vulgaris* L. ssp. *vulgaris* sensu Ford-Lloyd (1986).
- Cv. group Spinach Beet: *B. vulgaris* L. convar. *vulgaris* provar. *vulgaris* sensu Helm (1957), *B.*

vulgaris L. ssp. *vulgaris* convar. *cicla* (L.) Alef. var. *cicla* sensu Mansfeld (1986), *B. vulgaris* L. ssp. *cicla* (L.) Koch sensu Ford-Lloyd (1986).
- Cv. group Swiss Chard: *B. vulgaris* L. convar. *vulgaris* provar. *flavescens* DC sensu Helm (1957), *B. vulgaris* L. ssp. *vulgaris* convar. *cicla* (L.) Alef. var. *flavescens* DC sensu Mansfeld (1986), *B. vulgaris* L. ssp. *cicla* (L.) Koch sensu Ford-Lloyd (1986).

Vernacular names
- Cv. group Garden Beet (cultivars grown for the swollen hypocotyl and root): garden beet, beetroot (En). Betterave potagère (Fr). Indonesia/ Malaysia: bit. Philippines: remolatsa (Bisaya). Thailand: phakkat-daeng (central), phakkat-farang (Bangkok). Vietnam: c[ar]i d[uw][owf]ng, c[ur] d[eef]n.
- Cv. group Spinach Beet (cultivars grown for the leaves): spinach beet, leaf beet (En). Poirée à couper, poirée ordinaire (Fr). Indonesia: bit bodas.
- Cv. group Swiss Chard (cultivars grown for the enlarged petioles and midribs): Swiss chard (En). Poirée à carde, arde, côte de blette (Fr).

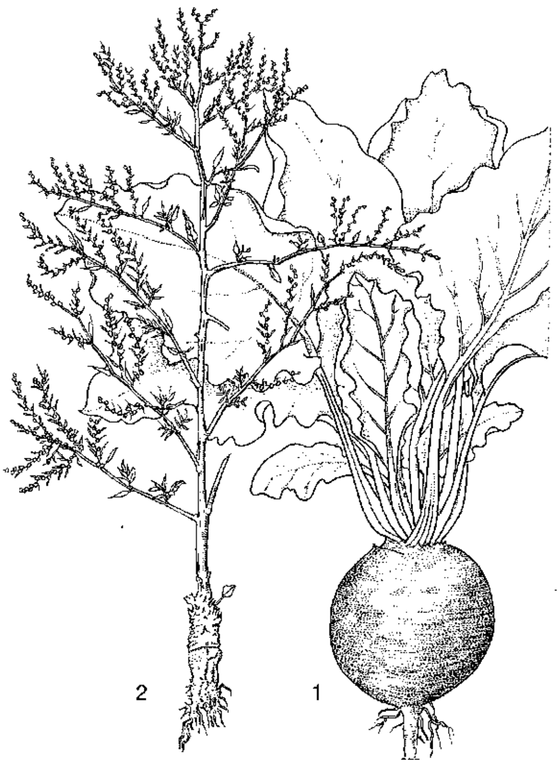
Origin and geographic distribution Wild forms of *B. vulgaris* occur along the shores of the Mediterranean, extending eastwards as far as Indonesia and westwards along the coasts of the Atlantic up to southern Norway. *B. vulgaris* was taken into cultivation in the eastern Mediterranean or the Middle East and first mentioned in the literature in Mesopotamia in the 9th Century BC. It followed the early trade routes to East Asia, reaching India in classical times and China by 850 AD. Originally, beets were grown mainly for their leaves. The first recorded recipes for the root date from the 3rd Century AD. Towards the end of the Middle Ages the garden beet, with its thick cylindrical or globular root, had become an important vegetable in central Europe. Very little is known of the development and early distribution of Swiss chard. Presently, beets are grown for their roots, petioles and leaves throughout the world. Garden beet is the most important form worldwide.

Uses The usually deep-red roots of garden beet are eaten boiled either as a cooked vegetable, or cold as a salad after adding oil and vinegar. A large proportion of the commercial production is processed into boiled and sterilized beets or into pickles. Spinach beet leaves are eaten as pot herb. Young leaves of the garden beet are used similarly, e.g. in Indonesia and Japan. The midribs of Swiss chard are eaten boiled like asparagus.
Roots and leaves are used medicinally against infections and tumours, and garden beet juice is a popular health food. Betanins, obtained from the roots, are used industrially as red food colourants, e.g. to improve the colour of tomato paste. Forms with strikingly coloured, large leaves are grown as ornamentals.

Production and international trade Europe and North America produce the bulk of the crop and their combined annual commercial production amounts to 900 000 t (excluding Eastern Europe). Spinach beet is important in northern India and parts of South and Central America, but no production figures are available. In most other areas beet crops are grown mainly for home consumption or local markets.

Properties Garden beet contains per 100 g edible portion (80% of the fresh root): water 89 g, protein 1.5–2.0 g, fat 0.1–0.2 g, carbohydrates 7–10 g, fibre 1–1.5 g, ash 1 g. The energy value is 160 kJ/100 g. The carbohydrates consist purely of saccharose. Compared with other vegetables, garden beet has a low mineral and vitamin content. Spinach beet, in contrast, has less energy value but is richer in vitamins and minerals. The nutritional value of Swiss chard is intermediate between Garden beet and Spinach beet.
The colouring agents in garden beet are not anthocyans, but heterocyclic nitrogen compounds: red betacyanins (betanins). Beets contain geosmin, which causes the typical earthy smell.
1000-seed weight is 5–10 g. Seeds are normally clustered into glomerules or seedballs. The weight of 1000 seedballs is 13–22 g.

Description A highly variable, robust, erect, usually biennial herb. Main root long, stout, tapered, side-roots forming a dense, extensive root system in the top 25 cm of the soil. In garden beet, the hypocotyl and the upper part of the main root are conspicuously swollen, being globular, flattened, cylindrical or tapering; adventitious roots occur in two opposite rows on the lower part; the swollen root consists of alternating layers of strongly coloured conductive tissue and light coloured storage tissue. In vegetative plants leaves grow in a basal rosette and have long petioles. Leaves alternate, often ovate and cordate, 20–40 cm long, margins wavy except in spinach beet, leaf tissue puckered between nerves, subglabrous, green, dark green or red, often shiny; leaves in the inflorescence passing into linear bracts; in Swiss chard the petiole and midrib are swollen. Inflorescence a long, paniculate, more or less open spike, 50–150 cm long; flowers greenish, sessile, bisexual, usually 2–3(–5) together, sub-



Beta vulgaris L. – 1, habit cv. group Garden Beet; 2, inflorescence.

tended by minute bracts; perianth 5-partite, becoming thicker at base as fruits ripen; stamens 5; ovary 1-celled, surrounded by a disk; pistil short with 2–3 stigmas. Fruit 1-seeded, enclosed within the swollen corky perianth-bases, 3–7 mm in diameter, 1–6 fruits adhering in groups called glomerules or seedballs. Seed kidney-shaped, brown, 1.5–3 mm in diameter and 1.5 mm thick.

Growth and development Beets are biennial plants requiring vernalization for flower induction. In cultivars of temperate areas 4–10°C for 2 weeks is sufficient to induce flowering. The low-temperature requirements in tropical selections are less. Long daylengths further promote flowering. Flowering in garden beet is also stimulated by high temperatures, which may lead to flowering during the first year in the tropics. This risk does not occur in Swiss chard and spinach beet. When grown for seed production, flowering can be obtained by using vernalized seed or seedlings. Pollination is mainly by wind, though flowers produce nectar and are visited by insects, especially thrips. Beets are selfincompatible.

Other botanical information At present it is quite generally accepted that the cultivated taxa of the genus *Beta* L. all belong to one species: *B. vulgaris* L. However, there is disagreement concerning the infraspecific classification and the classification of related wild taxa, together constituting section *Beta* of the genus *Beta*. There are almost no barriers to gene exchange between the wild and cultivated taxa and a pattern of continuous morphological variation is present.

In the literature the subclassification of *B. vulgaris* is confused and characterized by numerous ranks and names. As long as the phylogeny of the cultivated taxa is not known with certainty, it seems most appropriate to classify the cultivated taxa below species level only in cultivar groups and in cultivars, as has been done here. In this view, the other two cultivated *Beta* taxa, sugar beets and fodder beets, should be classified as *B. vulgaris* L. cv. group Sugar Beet and *B. vulgaris* L. cv. group Fodder Beet, respectively.

For the vegetable types, some cultivars recommended for the tropics are:

- cv. group Garden Beet: 'Crimson Globe' and 'Detroit Dark Red';
- cv. group Spinach Beet: no specific cultivars are known; all sold planting material is called spinach beet;
- cv. group Swiss Chard: 'Fordhook Giant' and 'Lucullus'.

The most recent revision of the wild *Beta* taxa within section *Beta* distinguishes 3 species: *B. vulgaris* L. (with ssp. *adanensis* (Pamukçuoglu) Ford-Lloyd & Williams, and ssp. *maritima* (L.) Arcangeli), *B. macrocarpa* Gussone and *B. patula* Aiton.

Ecology Temperatures over 25°C adversely affect growth and colour development of garden beet. An elevation of 600–1000 m in the tropics is the minimum for profitable production. Spinach beet and Swiss chard tolerate higher temperatures.

Beets require a fertile, moist soil for good growth. They prefer a neutral to slightly alkaline pH. As they originate from sea-shores, they are tolerant of limited concentrations of salt.

Propagation and planting Beets are always propagated by seed. Seed production in the tropics is difficult and seed is normally imported. Beets are sown 2–3 cm deep in rows (12.5–)25–30(–50) cm apart. Mostly, whole seedballs are sown, making thinning to single plants necessary. Monogerm seed, obtained through breeding or by dividing the seedballs, is available. As transplanting may give poor results and malformed roots, beets are often direct-seeded. However, Chinese gardeners normally transplant. The plant density depends on the purpose of the crop. For young, high quality minibeets the plant spacing may be as close as 12.5 cm × 5 cm, whereas for a crop of mature garden beets the plant spacing may be 25 cm × 10–13 cm. Spinach beet and Swiss chard are planted 5–25 cm apart, depending on the system of harvesting.

Husbandry Relatively large amounts of fertilizer are important for profitable yields. Nitrogen can be given as $NaNO_3$ in slightly acidic soils, or where available Na is limited. In some areas common salt is applied as a fertilizer or sprayed to stimulate beet growth and to kill small weeds. Where boron deficiency causes stunted and slow growth, 10–30 kg/ha of borax can be applied. However, too much boron may be toxic to the subsequent crop. For good growth, moist soil is required. Irregular irrigation may cause cracking of roots.

Diseases and pests Beets are generally not seriously attacked by diseases or pests. Downy mildew (*Peronospora parasitica*) transmitted by seed may cause red-rimmed spots on the leaves of adult plants. Another leaf disease is *Cercospora beticola*. *Phoma betae*, also transmitted by seed, may cause damping-off, as do *Pythium* and *Rhizoctonia*.
Larvae of beet web worms feed on leaves and produce webs. Occasionally aphids and beet leafminers are a problem. *Meloidogyne* root knot nematodes affect the roots of beets.

Harvesting Garden beets are often harvested with their leaves and tied into bunches of 3–4 and sold fresh. Harvesting is often by hand, but various kinds of mechanical root harvesters can be used. The time from planting to harvesting depends on the size of the roots preferred. Minibeets with a diameter of 3–4 cm can be harvested about 2 months after sowing, full-size beets after 3–4 months.
Spinach beet and Swiss chard are usually harvested by cutting the large, still vigorous, outer leaves with a knife. Harvesting can start about 45 days after sowing and can continue for up to 2 years in fertile soil. In closely spaced plantings, whole plants are sometimes harvested.

Yield With good cultivation techniques and effective weed control garden beet in the tropics may yield 15–25 t/ha. Swiss chard and spinach beet may yield 100 t/ha per year though much higher yields have been obtained under small-scale intensive cultivation.

Handling after harvest Garden beet can be stored for more than half a year under cool, well-ventilated conditions, provided the leaves are removed. The optimum temperature is 0–4°C at a relative humidity of 90–95%. Industrially, beets are preserved after steam-boiling and skinning and addition of vinegar, either as whole minibeets or sliced.

Genetic resources Genetic material collected for breeding work in sugar beet and fodder beet can be used in breeding vegetable beets. Collections of wild and cultivated *Beta* material from the eastern Mediterranean and secondary centres of diversity are kept by sugar beet breeders in Western Europe and North America. The genus *Beta* has a high priority for IBPGR since diversity is rapidly eroding.

Breeding Most breeding work is done in temperate countries, but also in southern China, Hong Kong and northern India. Breeders of garden beet aim at rapid root formation, limited leaf production and petioles narrow at their base, good homogeneous colour, good shape, appearance and taste, and no bolting in the first year.

Prospects Spinach beet and Swiss chard, with their high productivity and high nutritional value, merit more attention as market vegetables in the cooler parts of the tropics. Garden beet is mostly grown for the European cuisine. The absence of serious diseases and pests and the good transport and storage characteristics are commercially attractive.

Literature |**1**| Knott, J.E. & Deanon Jr, J.R. (Editors), 1967. Vegetable production in South-East Asia. University of the Philippines Press, Los Baños, the Philippines. pp. 290–292, 305–317. |**2**| Krug, H., 1991. Gemüseproduktion [Vegetable production]. 2nd edition. Verlag Paul Parey, Berlin, Germany. pp. 287–294. |**3**| Letschert, J.P.W., 1993. Beta section Beta: biogeographical patterns of variation and taxonomy. Thesis. Wageningen Agricultural University Papers 93–1, Wageningen, the Netherlands. 154 pp. |**4**| Messiaen, C.-M., 1974. Le potager tropical [The tropical vegetable garden]. 2. Cultures spéciales [2. Special crops]. Presses Universitaires de France, Paris, France. pp. 374–379. |**5**| Nonnecke, I.L., 1989. Vegetable production. Van Nostrand Reinhold, New York, United States. pp. 347–353, 500–504. |**6**| PAGV, 1988. Teelt van kroten [Cultivation of beetroot]. Teelthandleiding No 24. Proefstation voor de Akkerbouw en de Groenteteelt in de Vollegrond (PAGV), Lelystad, the Netherlands. 51 pp. |**7**| Tindall, H.D., 1968. Commercial vegetable growing. Oxford University Press, United Kingdom. pp. 119–122.

L.P.A. Oyen

Brassica L.

Sp. pl.: 666 (1753); Gen. pl. ed. 5: 299 (1754).

CRUCIFERAE

$x = 8$ (genome B), 9 (genome C), 10 (genome A); $2n = 16$ (BB, *B. nigra*), 18 (CC, *B. oleracea*), 20 (AA, *B. rapa*), 34 (BBCC, *B. carinata*), 36 (AABB, *B. juncea*), 38 (AACC, *B. napus*).

Major species and synonyms
- *B. carinata* A. Braun, Flora 24: 267 (1841), synonym: *B. integrifolia* (West) Thellung var. *carinata* (A. Braun) O.E. Schulz (1919).
- *B. juncea* (L.) Czernjaew – see separate article.
- *B. napus* L., Sp. pl.: 666 (1753), synonyms: *B. campestris* DC. (1821) non L. (1753), *B. campestris* L. ssp. *napus* (L.) Hooker (1872) – see chapter on Minor Vegetables.
- *B. nigra* (L.) Koch, Deutschld. Fl. ed. 3, 4: 713 (1833), synonyms: *Sinapis nigra* L. (1753), *B. sinapoides* Roth (1830), *Sisymbrium nigrum* (L.) Prantl (1884).
- *B. oleracea* L. – see separate articles.
- *B. rapa* L. – see separate articles.

Vernacular names
- *B. carinata:* Ethiopian mustard (En). Moutarde éthiopienne (Fr).
- *B. juncea:* Indian mustard, Chinese mustard, vegetable mustard (En).
- *B. napus:* Colza, rape, rutabaga (En). Colza, rutabaga (Fr).
- *B. nigra:* Black mustard (En). Moutarde noire (Fr).
- *B. oleracea:* Cole crops (En).
- *B. rapa:* Neep crops (En).

Origin and geographic distribution The six cultivated *Brassica* species are all native to the Eurasian continent. Many of their crops are now cultivated worldwide. It is generally agreed that the three diploid species, i.e. *B. nigra, B. oleracea* and *B. rapa*, are the parents of the amphidiploid species, i.e. *B. carinata, B. juncea* and *B. napus,* which must have originated through interspecific hybridization between the primary species under domestication.

The three primary species occur wild and in cultivation.
- *B. nigra* occurs wild in the Mediterranean, on the Ethiopian plateau, in the Middle East and throughout central Europe. It is cultivated in various parts of the world.
- *B. oleracea* occurs in the wild, together with related wild species, along the coasts of the Mediterranean and as far north as the coasts of England. The amazing range of cole crops was domesticated in Europe, and many of them are now grown all over the world.
- *B. rapa* occurs in wild forms in central Asia. The turnip appears to be the most ancient crop, domesticated in a rich variety both in Europe and Japan. An impressive range of leafy vegetable crops developed in Asia (China and Japan). Oilseed forms have been cultivated since ancient times in the south of the Indian subcontinent, where they are still important.

The three amphidiploid species are only known from cultivation.
- *B. carinata* (*B. nigra* × *B. oleracea*) is mainly grown at present in a part of the East African Plateau, especially Ethiopia, but is also encountered occasionally on the east and west coasts of Africa.
- *B. juncea* (*B. nigra* × *B. rapa*) probably originated in Central Asia where both parental species occur, and where oilseed types are predominant. In China a great variety of vegetable types evolved.
- The biennial forms of *B. napus* (*B. oleracea* × *B. rapa*) originated in western Europe, the annual type probably being a derived form. It is now mainly grown in Europe and Canada.

In South-East Asia *B. juncea, B. oleracea* and *B. rapa* are cultivated in great quantity. *B. carinata, B. napus* and *B. nigra* occur only occasionally if at all.

Uses *Brassica* shows an unparalleled diversity of crop forms and utilization. Brassicas are raised for vegetable (swollen root and stem, leaves, flower buds, curd), fodder, as dried, salted and pickled foods such as sauerkraut, as accessories to meat dishes, for oil and table mustard from the seed, and for medicinal and ornamental uses.
- *B. nigra:* the seeds are used for table mustard.
- *B. oleracea*: all parts are used as vegetable and as fodder; the cole crops comprise cabbages, cauliflower, broccoli, Chinese kale, Brussels sprouts, kohlrabi, borecole and kales.
- *B. rapa:* the seed is used for oil production (turnip rapes); all other parts are used as vegetable and as fodder (worldwide); the vegetable crops comprise Chinese cabbage, pak choi, caisin, vegetable turnip, turnip greens, mizuna, taatsai.
- *B. carinata:* oil from the seeds is its major use,

but the leaves are also used as a vegetable (Ethiopia).
- *B. juncea:* the seeds are used for oil extraction (India) and for table mustard (worldwide); the leaves, stems, shoots and roots are used as vegetable (China, South-East Asia).
- *B. napus:* the seeds are used for oil production (Europe, Canada); the green parts and the swollen roots (rutabaga) are used as forage and as vegetable (Europe, North America, Russia).

Production and international trade Most *Brassica* vegetables and fodder crops are destined for fresh consumption and have to be marketed and consumed within a few days after being harvested. Local production, marketing and consumption are therefore the main features, often escaping official statistics, but the importance of this group of vegetables can hardly be overestimated. In large parts of Asia, *Brassica* crops should be considered as staple food.

Properties All *Brassica* crops contain glucosinolates which in crushed leaves are broken down by the enzyme myrosinase yielding bitter-tasting goitrogenic substances: isothiocyanates, thiocyanates, nitriles and goitrin. At an early stage in domestication, selection for less bitter-tasting individuals must have taken place, because in wild cabbage bitter-tasting principles can be present in up to four times the amount found in cabbage eaten by man.

Description Annual or biennial, rarely perennial herbs, with taproot that may be fleshy. Stem erect or ascending, glabrous or with simple hairs, sometimes very glaucous. Lower basal leaves often pinnatifid with large terminal lobe. Inflorescences ebracteate racemes; sepals 4; petals 4, long-clawed, usually yellow; stamens 6, 2 short, 4 long. Fruit a silique with convex valves, tipped by an indehiscent seedless beak. Seeds in a single row in each loculus, spherical, brown-black or yellowish. Germination is epigeal.
Some general characteristics of the three major species cultivated in South-East Asia:
- *B. juncea.* Annual or biennial herb, usually with firm taproot and erect, much branched stem. Leaves thin, green or thinly glaucous, more or less pilose; lower leaves lobed, usually with a large apical lobe; leaves gradually becoming smaller towards the apex of the stem, often narrowly oblanceolate finally. Flowers small, usually less than 1 cm wide and long, buds positioned just below the expanded flowers. Fruit 2–8 cm long, beak short and stout.
- *B. rapa.* Annual or biennial herb with firm or tuberous taproot and erect, branched stem. Leaves often slightly glaucous and clasping the stem, more or less pilose; lower leaves lobed, usually with a large apical lobe and with a petiole; upper leaves sessile, undivided. Flowers small, up to 1 cm long with sepals spreading, buds positioned just below the expanded flowers. Fruit 4–10 cm long, beak up to 3 cm long.
- *B. oleracea.* Annual or biennial herb with very strong taproot, but never with swollen roots. Stem erect and strong, sometimes fleshy and swollen. Leaves rather thick, glaucous, glabrous, very variable in shape, colour, size and thickness. Flowers rather large, up to 2 cm long, buds raised far above the expanded flowers. Fruit 5–10 cm long, beak tapering.

Brassica juncea (L.) Czernjaew – 1, flowering shoot with leaves; 2, flowering and fruiting shoot; 3, seed.

Growth and development The vegetative growth phase of *B. juncea* (AABB) and *B. rapa* (AA) is a rosette, while *B. oleracea* (CC) grows an elongated stem. In the annual forms these phenomena are often masked because of very early bolting. The *B. oleracea* winter vegetables of temperate climates (cabbages and kales) can only be vernalized when they have at least 6 well-developed leaves, at temperatures below 8°C during up to 3 months. Biennial forms of *B. juncea* and *B. rapa* may be induced to flower by exposing pre-germinated seed or seedlings to low temperatures for up to 2 months. Annual forms will flower rapidly when exposed to long daylengths and/or high temperatures. Early flowering induction will make plants skip the commercial sink (cabbage head, turnip), resulting in a short generation cycle, a phenomenon most important for breeding. *Brassica* species are entomophilous, the diploid species are cross-fertilizing and *B. napus* (AACC) is self-pollinating. However, detailed studies are lacking.

Other botanical information The taxonomy of the *Brassica* crops is confused and overloaded with names and botanical classification systems, no single one being clear and distinctive for all existing taxa. Infraspecific classification may be done more conveniently by grouping cultivars into cultivar groups. First attempts towards such classifications, however, are far from being complete and generally accepted.

Several parallel variations are manifest in the *Brassica* species. The most obvious character is the swollen hypocotyl and root, producing a wide range of turnip morphotypes in *B. rapa* (AA). In both amphidiploid species carrying the A genome, *B. napus* (AACC) and *B. juncea* (AABB), similar crops exist. The range of rutabaga (*B. napus*) morphotypes is practically the same as in *B. rapa* and difficult to distinguish. Less obvious, but most important for crop production, is the phenomenon of the vegetative stem in *B. oleracea* (CC), which is on the one hand the basis of the kale crops and Brussels sprouts, whereas the short stem inside the cabbage gives it the high degree of compactness. Vegetative stems are also apparent in *B. carinata* (BBCC) and *B. napus* (AACC), making them suitable leafy fodder crops, but no vegetable types like the cole crops were domesticated.

Ecology Most *Brassica* crops originated in temperate regions and grow best in cool moist climates and at higher altitudes in the tropics. They are not really suited to the lowland humid tropics. The ideal soil is a rich sandy loam.

Agronomy All *Brassica* crops are grown from seed. When moistened, seeds germinate immediately and seedling growth is rapid and uniform. Sowing is done in nurseries or boxes or directly in the field. Land should be well prepared before planting. The crops respond well to organic manure and mineral fertilizer, particularly to nitrogen. Weeding is very important. Notorious diseases and pests are: black leg (*Phoma lingam*), black rot (*Xanthomonas campestris*), downy mildew (*Peronospora parasitica*), clubroot (*Plasmodiophora brassicae*), cabbage mosaic virus, root-knot nematode (*Meloidogyne* spp.), cabbage white butterfly (*Ascia monuste*), cabbage budworm (*Hellula phidilealis*), diamond-back moth (*Plutella xylostella*). Snails and slugs can cause much damage. *Brassica* field crops are known in Europe to be good 'break' crops with an improving effect on other crops in the rotation. Some care has to be taken to prevent *Brassica* crops from escaping from cultivation and becoming weeds. This danger is due to the shattering nature of the siliques and the small oilseed that survives in the soil for many years and readily germinates under suitable conditions.

Genetic resources and breeding The demand of vegetable growers throughout the world for F_1 hybrids is resulting in the replacement (loss) of most landraces and open-pollinated cultivars. This replacement is virtually complete in Europe, North America, Japan and Korea. Most genetic variation has been collected. World collections are kept in gene banks in Tsukuba (Japan), in Wellesbourne (United Kingdom), Wageningen (the Netherlands), Braunschweig (Germany) and in Beltsville (United States). A network is operational and coordinated by the International Board for Plant Genetic Resources (IBPGR).

Mastery of flowering is the key to success in *Brassica* breeding. With adequate facilities for flowering induction three generations may be grown in a year. Disease-resistant cultivars and cultivars which will thrive in the low hot humid tropics are urgently required.

Prospects The *Brassica* crops with their perplexing variability will remain important all over the world. In general they are easy to grow, for home consumption as well as for commercial purposes, and their nutritional value is good. In South-East Asia, research should focus on the forms available in endless variation in China and Japan.

Literature |1| Bailey, L.H., 1922, 1930. The cultivated Brassicas, Part 1 and 2. Gentes Herbarium 1: 53–108 (Part 1, 1922), 2: 210–267 (Part 2, 1930). |2| Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 182–224. |3| IBPGR, 1981. Genetic resources of cruciferous crops. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 48 pp. |4| Nieuwhof, M., 1969. Cole crops. Leonard Hill, London, United Kingdom. 353 pp. |5| Sinskaia, E.N., 1928. The oleiferous plants and root crops of the family Cruciferae. Bulletin of Applied Botany, Genetics and Plant Breeding 19: 555–626. |6| Toxopeus, H., 1974. Outline of the evolution of turnips and coles in Europe and the origin of winterrape, swede-turnips and rape kales. Proceedings of the Eucarpia Meeting on Cruciferae, Dundee, 25–27 September, 1974. pp. 1–7. |7| Toxopeus, H., Oost, E.H. & Reuling, G., 1984. Current aspects of the taxonomy of cultivated Brassica species. Cruciferae Newsletter No 9: 55–58. |8| Tsunoda, S., Hinata, K. & Gomez-Campo, C. (Editors), 1980. Brassica crops and wild allies: biology and breeding. Japan Scientific Societies Press, Tokyo, Japan. 354 pp.

H. Toxopeus & P.C.M. Jansen

Brassica juncea (L.) Czernjaew

Consp. pl. Chark.: 8 (1859).
CRUCIFERAE
$2n = 36$

Synonyms *Sinapis juncea* L. (1753), *S. timoriana* DC. (1821), *Brassica integrifolia* (West) Rupr. (1860).

Vernacular names Indian mustard, Chinese mustard, vegetable mustard (En). Moutarde indienne, moutarde de Chine (Fr). Indonesia: sawi, sesawi. Malaysia: sawi pahit, kai choy. Philippines: mustasa (Tagalog). Cambodia: khat naa. Laos: kaad khièw. Thailand: phakkat-khieo, phakkat-khieopli (central). Vietnam: c[ar]i canh, c[ar]i b[ej] xanh.

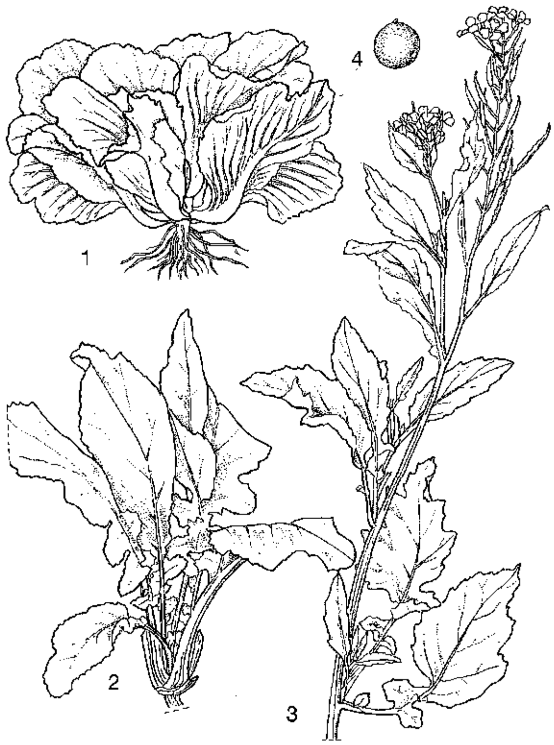
Origin and geographic distribution *B. juncea* crops are grown worldwide, from India to northern Africa, to Central Asia (southern and south-eastern part of the former Soviet Union), to Europe and North America. The exact origin is unknown, but as an amphidiploid it seems logical that it originated in an area where the parental species, *B. nigra* (L.) Koch and *B. rapa* L., overlap in their distribution (e.g. Central Asia). It is generally agreed that the primary centre of diversity of *B. juncea* is Central Asia (North-West India, including the Punjab and Kashmir) with secondary centres in central and western China, Hindustan (East India and Burma) and Asia Minor (through Iran). In *B. juncea* two types of mustards with varying usage have evolved, i.e. oilseed types and vegetable types. The oilseed types (oilseed mustard) are particularly important in India, Bangladesh and China. The vegetable types comprise forms with edible leaves (leaf mustard), stems (stem mustard) and roots (root mustard). The vegetable mustards are widely cultivated in Asian countries. The highest degree of variation occurs in China, which is regarded as the primary centre of varietal differentiation. The early Chinese traders might well have carried the crop into South-East Asia, whereas the appearance of *B. juncea* near European ports suggests a connection with grain imports. It has also been suggested that Indian contract labourers brought it to the West Indies. In South-East Asia it is the leaf mustards which are most common.

Uses In eastern Asia, leaf mustard is consumed mainly after pickling. It is eaten in great quantity in China and Korea and many cultivars are available. In South-East Asia, it is used as fresh green, cooked or pickled, and is well-liked for its special flavour and pungent taste.

Production and international trade Leaf mustard is not a significant product of commerce in international trade, except when the foreign market is close to the production areas. This is partly due to its highly perishable nature. Nearly 100% of the domestic production in many countries is consumed locally. In Indonesia leaf mustard is a minor vegetable and not separately accounted for in production statistics. Although no total production was reported, Malaysia had a total of 1250 ha under leaf mustard in 1985. Malaysia exported 2000 t to neighbouring Singapore in 1983, comprising 99% of the total leaf mustard imports of the latter. In the Philippines, 27 230 t were produced from an area of 2300 ha in 1986. In Thailand 43 000 t were produced from 4400 ha in 1988. The heading type is exported in cans from Thailand.

Properties Per 100 g edible portion fresh leaf and stem contain approximately: water 92 g, protein 2.4 g, fat 0.4 g, carbohydrates 4 g, Ca 160 mg, Fe 2.7 mg, vitamin A 1.8 mg and vitamin C 73 mg. Cooking is known to decrease vitamin C; drying and pickling are known to decrease both vitamins A and C. The pungency is caused by the volatile mustard oil, present in all parts. The 1000-seed weight is about 2 g.

Description Erect annual to biennial herb, 30–160 cm tall, normally unbranched, sometimes with long ascending branches in upper part, subglabrous, subglaucous. Taproot sometimes enlarged (root mustard). Leaves very variable in shape and size, pinnate or entire, petioled, pale to dark green, smooth or pubescent, heading or non-heading. Inflorescence a corymbiform raceme, rather loose with numerous flowers, up to 60 cm



Brassica juncea (L.) Czernjaew – 1, habit cv. group Head-leaf Mustard; 2, habit cv. group Broad-leaf Mustard; 3, flowering and fruiting shoot; 4, seed.

long; flowers perfect; pedicel ascending, 5–12 mm long; sepals 4, oblong, 4–6 mm long, green; petals 4, clawed, blade obovate, 6–10 mm long, bright yellow; stamens 6, tetradynamous; stigma globose. Fruit a silique (more than 3 times as long as broad), linear, somtimes inflated and often torulose, 25–75 mm × 2–3.5 mm, attenuate into a conical beak, dehiscent, containing 10–20 seeds. Seed globose, 1–1.5 mm in diameter, finely reticulated, brown to grey-black.

Growth and development Seeds of vegetable mustard exhibit slight dormancy, but when properly dried they may germinate soon. However, it is generally advisable to wait for at least two weeks after drying before sowing them. Germination requires about 3–5 days given optimum soil moisture and temperature (about 20–25°C). In the warm tropical lowlands, leaf mustard grows fairly rapidly to develop succulent leaves. The growth and development period prior to harvest can be as short as three weeks from transplanting (the plant then has about 6–8 fully expanded leaves), but can be longer if larger plants are preferred in the market. Bolting and flowering generally do not require very low temperatures and can easily be induced by long days in the temperate zones. Some types are neutral to both daylength and temperature. Bolting is generally indicated by the elongation of the main stem as the flower buds initiate and grow. Axillary flowering branches develop in a similar manner. The bright yellow flowers attract bees (often honeybees) to effect natural cross pollination. After fertilization, the thin, slender siliques develop rapidly and reach full length some three weeks or so later and are ready for harvest in another two-week period.

Other botanical information *B. juncea* evolved as an amphidiploid species ($2n = 36$), derived from the natural hybrid between black mustard (*B. nigra*, $2n = 16$) and neep (*B. rapa*, $2n = 20$).

It is a very polymorphic species and it has been classified and described under various specific and varietal names, which has resulted in a very confused taxonomy.

The variability of *B. juncea* can best be classified at cultivar level. 'Indian mustard' should be maintained as the common name for the species *B. juncea*. Based on the morphotypes distinguished by Shi-ru Chen for China, the following cultivar groups are tentatively proposed to classify the vegetable mustards (the oilseed types are grouped in a separate cv. group Oilseed Mustard, and will be dealt with in the Prosea volume on 'Vegetable oils and fats'):

- cv. group Broad-leaf Mustard: large plants with broad and large, green or purple leaves; leaf margins entire, undulate or dentate; few leaves are slightly lobed; common in South-East Asia.
- cv. group Dissected-leaf Mustard: plants having leaves which are variously dissected.
- cv. group Head-leaf Mustard: plants with large leaves with broad petioles and midribs; the youngest leaves fold inward, the next overlapping each other, together forming a globose head; common in South-East Asia.
- cv. group Strumiferous-leaf Mustard: plants with large leaves and well-developed petioles with tumour-like protuberances at the top.
- cv. group Tillering Mustard: plants with many vigorous lateral buds on a shortened stem which grow into 'tillers' before flowering; cultivars often referred to as pot-herb mustards.
- cv. group Stem Mustard: biennial plants with swollen stems which are rod-shaped or variously enlarged with tumour-like protuberances just below the petioles; leaves large, green or purple,

smooth or rugose, entire or dissected. Zacai is a processed product of this group, crisp and tender and very popular because of its flavour.

- cv. group Shoot Mustard: erect annual or biennial plants; leaves oblong or ovate, entire to slightly dissected; shoots are swollen.
- cv. group Root Mustard: plants with inflated fleshy cylindrical or conical taproots; leaves green or purple, entire or dissected.

Ecology The leaf mustards have the best tolerance to high temperatures and humidity among the allied species, providing a good supply of leafy greens when the cool season cabbages could not. Its ecological complementarity with the cool season cabbages enabled mustard to develop as an important vegetable because it did not have to compete with the high-yielding crucifers such as Chinese cabbage. It has also basically determined the distribution of the two types. In the tropics, Chinese cabbage is commonly grown in the cooler highland areas whereas the leaf mustards are widely grown in the lowlands. The leaf mustards grow best in fertile, well-drained loamy soils that are relatively rich in organic matter. As vegetables, the leaf mustards have a wide variation in flowering behaviour. Seeds of the most commonly grown cultivars can be produced easily in the tropics, even under lowland conditions of the tropical fringes. Ordinarily, however, good seed development requires moderately cool and dry conditions which are often obtained only at medium to high elevations in the tropics.

Propagation and planting The leaf mustards are propagated by seed and can be direct-seeded or transplanted. Direct seeding is labour-intensive because well-prepared field beds are necessary and close attention to thinning and weeding is required. Seedlings for transplanting are often nursed in special nurseries, consisting of well-prepared raised beds about 1 m wide (no large clods of soil and relatively free of weeds and disinfected with chemicals if necessary to kill harmful diseases and insects) or in specially prepared seed boxes.

Seeds are broadcast or sown in shallow furrows, covered lightly with soil or with a finely sieved soilsand-compost mixture and then adequately watered. Seeds may be previously dusted with thiram to fend off attack by harmful diseases such as damping-off. In the tropics, the nursery is often covered with rice straw, banana leaves or palm fronds to prevent drying out through the intense sunlight. Watering twice to three times a day is necessary to keep the soil moist and the young plants growing vigorously. Sometimes seedlings are watered once a week with a 0.1–0.3% urea or ammonium sulphate solution, to enhance plant vigour. Seedlings are hardened by lightly withholding water about one week before transplanting. Three-week-old seedlings with about 3–4 true leaves are ready for transplanting. They must be planted out in such a way that the first true leaves are at about ground level when the hole is filled with soil. Transplanted seedlings do better if watered quickly after they have been planted.

Husbandry Field beds should be well-prepared; they are often raised and about 1 m wide with a furrow space of 20–25 cm. Basal fertilizer plus compost are often incorporated into the soil during the preparation of the field beds. Leaf mustards respond well to compost and fertilizer amendments. Often, 10 t/ha of compost (decomposed plant material or manure) combined with 90–100 kg/ha of N and 90 kg/ha each of P_2O_5 and K_2O are more than adequate to sustain a good crop. Normally, split application of N is practised, half of the total applied as basal fertilizer and the other half often side-dressed two weeks or so later.

Between-plant spacing varies depending upon how large the plants are to be allowed to grow for consumption, but often this ranges from 10–20 cm. Spacing between the rows could be 30–40 cm but may be less with more rows planted per bed.

The leaf mustards grow relatively rapidly and obtain maximum growth and tenderness only if supplied with adequate moisture. The application of 25 mm of water every fourth day appears to be a suitable practice. Weeds must be hoed during the early growth stages until the plants shade the unoccupied spaces. The quick growth and close spacing of leaf mustards normally take care of the weed problem afterwards.

Diseases and pests Important diseases are soft rot (*Erwinia carotovora*), downy mildew (*Peronospora parasitica*), turnip mosaic virus (TuMV), clubroot (*Plasmodiophora brassicae*) and *Alternaria* leaf-spot (*A. brassicae* or *A. brassicicola*). Soft rot is most damaging during the hot and humid season. No effective control measures have been developed; however, early cultivars or shortened growing schemes are known to enable crucifers to escape the disease. A number of fungicides (e.g. dithane, maneb, zineb, etc.) effectively control downy mildew and *Alternaria* leaf-spots. TuMV which is serious in the mustards during the dry season can be reduced by controlling aphids which act as the vector. Liming is known to minimize incidence of clubroot. Field sanitation to re-

duce the spread of clubroot to clean fields should be rigorously observed.
Foremost among the insect pests is diamond-back moth (*Plutella xylostella*), a globally important pest of crucifers. It is most prevalent during the cool dry period. A number of pesticides are used by farmers but invariably the insect develops resistance to chemicals quickly and pesticides generally degrade the environment. The efficacy of newly introduced pesticides often does not go beyond 2–3 years. Integrated pest management (IPM) using biological parasites (e.g. *Diadegma eucerophaga* and *Apanteles plutellae*) combined with selective microbial insecticides such as *Bacillus thuringiensis* may provide a satisfactory control. More importantly, IPM is safer for the consumer and more sustainable, but IPM technology still is seldom used by farmers in South-East Asia. Other pests such as webworm (*Hellula undalis*) and leaf webber (*Crocidolomia binotalis*), aphids (especially during the dry period) and striped flea beetle (*Phyllotreta striolata*) occasionally pose appreciable production problems.

Harvesting In Asia, the entire young plants (about 20–30 cm tall with about 6–8 fully expanded leaves) are uprooted or cut at ground level with a knife, or single leaves may be snipped off when about 20 cm or so long. About five once-a-week harvests, starting about three weeks or so after transplanting, could complete the harvesting of the transplanted crop. For a direct-seeded crop, twice-a-week harvests for 5–7 weeks are normally necessary. Harvesting during the hottest part of the day should be avoided because the leaves or uprooted plants lose water and wilt very quickly.

Yield The yield of leaf mustards has been estimated at 9–40 g per m^2 per day of growth. In South-East Asia, reported average yield was 3–10 t/ha in 1984–85. In Taiwan, average yield was 21 t/ha in 1989. Average yield was 11.6 t/ha in the Philippines in 1986 and 9.8 t/ha in Thailand in 1988.

Handling after harvest Harvested plants should be covered quickly with wet materials such as burlap bags or other suitable materials or put in the shade quickly to minimize water loss. The harvested plants are then washed well and cleaned of old, decaying, injured or unsightly leaves to prepare them for the market. The harvested plants or leaves could be packed in suitable containers, often 10-kg type bamboo baskets in the Asian tropics but other materials such as plastic boxes or paper cartons with holes to allow air circulation are used if locally available and inexpensive.

Genetic resources China is considered as the centre of varietal differentiation of the leaf mustards and is one of the richest sources of germplasm. Many institutional collections of *B. juncea* (oilseed and leaf type) exist throughout the world. Major collections are available in Australia, Canada, China (including Taiwan), Germany, India (especially landraces of the oilseed type), Japan, and the United States.

Breeding Breeding of mustard has emphasized its improvement as an oilseed crop. No major breeding programme to improve the leaf mustard is known. Whatever improvements have been attained in commonly grown cultivars must have arisen from the efforts of farmers and seed producers to select only the superior plants for seed production. However, very little genetic improvement is expected from these efforts. Very little effort is expended by national programmes in selecting the best adapted cultivars, although a few trials of introduced cultivars have been reported occasionally.

Prospects The potential to genetically improve the leaf mustards is great. Large collections, including those of the oilseed type, are available from various institutes. These resources will probably provide an adequate genetic reservoir for resistance to the major diseases and other desirable characters. Leaf mustards should thus be amenable to genetic improvement. Breeding could begin with more deliberate cultivar introduction and testing. Simple population breeding techniques such as mass selection, especially among genetically variable and highly adapted landraces, could lead to rapid improvement. Besides breeding, the control of pests, particularly insects such as diamond-back moth, through integrated pest management is a high priority to the national programmes of South-East Asia. The prospects for developing IPM technology to control insect pests in the hot and humid lowland areas are good.

Literature |1| Asandhi, A.A. & Sastrosiswojo, S., 1988. Research on vegetables in Indonesia. In: AVRDC, 1988a. Vegetable research in South-East Asia. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. pp. 95–102. |2| Bantoc Jr, G.B., 1967. Chinese cabbage and the mustards. In: Knott, J.E. & Deanon Jr, J.R. (Editors): Vegetable production in South-East Asia. University of the Philippines Press, Los Baños, the Philippines. pp. 276–284. |3| Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 211–224. |4| Nishi, S., 1980. Differentiation of

Brassica crops in Asia and the breeding of 'Hakuran', a newly synthesized leafy vegetable. In: Tsunoda, S., Hinata, K. & Gomez-Campo, C. (Editors): Brassica crops and wild allies: biology and breeding. Japan Scientific Societies Press, Tokyo, Japan. pp. 133–150. |5| Saharan, H.A. 1988. Research on vegetables in Malaysia. In: AVRDC, 1988a. Vegetable research in South-East Asia. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. pp. 65–72. |6| Shi-ru Chen, 1982. The origin and differentiation of mustard varieties in China. Cruciferae Newsletter No 7: 7–10. |7| Too, K.H. Christopher, 1970. Identification of some common Brassica species by their vegetative characters. The Malayan Agriculturist 9: 53–70. |8| Valmayor, R.V. & Tiamzon, M.F., 1988. Vegetable production and research policy in the Philippines. In: AVRDC, 1988a. Vegetable research in South-East Asia. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. pp. 17–30.

R.T. Opeña

Brassica oleracea L.

Sp. pl.: 667 (1753).
CRUCIFERAE
$2n = 18$

Major taxa and synonyms Cv. group names are proposed here.
- Cv. group Brussels Sprouts. Synonym: *B. oleracea* L. var. *gemmifera* DC. (1821).
- Cv. groups Cauliflower & Broccoli. Synonyms: *B. oleracea* L. var. *botrytis* L. (cauliflower), *B. oleracea* L. var. *italica* Plenck (broccoli) – see separate article.
- Cv. group Chinese Kale. Synonym: *B. oleracea* L. var. *alboglabra* (L.H. Bailey) Musil – see separate article.
- Cv. groups of other Kales. Synonym: *B. oleracea* L. var. *acephala* DC. (1821). Many groups are distinguished, e.g. cv. group Borecole or Curly Kale (syn.: var. *sabellica* L. (1753), var. *laciniata* L. (1753); cv. group Collard (syn.: var. *viridis* L. (1753), var. *plana* Peterm. (1838); cv. group Marrowstem Kale (syn.: var. *medullosa* Thellung (1918); cv. group Palmtree Kale (syn.: var. *palmifolia* DC. (1821); cv. group Portuguese Kale (syn.: var. *costata* DC. (1821); cv. group Thousand-headed Kale (syn.: var. *ramosa* DC. (1821), var. *millecapitata* (Lév.) Helm (1959).
- Cv. group Kohlrabi. Synonym: *B. oleracea* L. var. *gongylodes* L. (1753).
- Cv. groups White Headed Cabbage, Red Headed Cabbage and Savoy Headed Cabbage. Synonyms: *B. oleracea* L. var. *capitata* L. (white and red cabbage), *B. oleracea* L. var. *sabauda* L. (savoy cabbage) – see separate article.

Vernacular names General: Cole crops (En).
- Cv. group Brussels Sprouts: Brussels sprouts (En). Chou de Bruxelles (Fr). Cambodia: spéi tôôch tôôch. Thailand: kalam-dao.
- Cv. groups of Kales: Kale (En). Chou vert (Fr). Philippines: kales, kolis (Tagalog). Cambodia: spéi barang. Thailand: khana-farang.
- Cv. group Kohlrabi: Kohlrabi, turnip kale (En). Chou rave (Fr). Thailand: kalam-pom. Vietnam: su h[af]o, th[of] l[of].

Origin and geographic distribution Wild cabbage (*B. oleracea* L. var. *oleracea*) is indigenous to the Mediterranean region, south-western Europe, and southern England where it grows on sea cliffs. It was brought into cultivation about 5000 years ago and gave rise to numerous cultivated forms, varying widely in vegetative morphology. Probably other wild species (e.g. *B. cretica* Lamk, *B. insularis* Moris and *B. rupestris* Raf.) were also involved in the origin of the present-day richness of forms and cultivars of *B. oleracea*. Cole crops are cultivated all over the world, but are most important in temperate climates.

Brussels sprouts originated in the 18th Century in Belgium and became established as an important vegetable crop in north-western Europe. Early-maturing Asian types have been developed in Japan.

Kales are ancient cole crops, closely related to the wild forms of *B. oleracea*. Many distinctive types were developed in Europe such as thousand-headed kale, marrowstem kale, collards and curly kale, the latter two being the most important as vegetables.

Kohlrabi first appeared in the Middle Ages in central and southern Europe. The crop has become established in parts of Asia over the course of the last two centuries and is important in China and Vietnam.

These cole crops are grown in many temperate countries and on a small scale at higher elevations in tropical areas such as South-East Asia.

Uses The main use of *B. oleracea* is as a vegetable, although some forage cultivars exist as well. Depending on cultivar, the stem, the leaves or the inflorescence, or a combination of these, form the edible parts.

In Brussels sprouts it is the miniature axillary heads (leaves) which are consumed as a cooked vegetable. The kales are a polymorphic group comprising vegetable types (curly kale, collard) and types mainly used as fodder crops (thousand-headed kale, marrowstem kale, collard). The vegetable types are grown for their smooth or curly foliage, usually consumed cooked. Kohlrabi is principally grown for its swollen stem, which is used cooked. The foliage can be consumed as well. Kohlrabi is also an important fodder.

Production and international trade Brussels sprouts, curly kale and kohlrabi are popular vegetables in temperate regions, the first two especially during the winter months. Only kohlrabi has developed a strong foothold in mainland Asia (China, Vietnam). In Malesia they are minor crops cultivated at higher elevations. No production statistics are available.

Properties Per 100 g edible portion, kale comprises: water 82–88 g, protein 3.9 g, fat 0.7 g, carbohydrates 6.6 g, fibre 1.2 g, carotene 3.2–4.5 mg, vitamin C 35–115 mg, Ca 200–329 mg, P 58–87 mg, Fe 1.0–1.9 mg. The energy value is 185 kJ/100 g. Brussels sprouts have a similar composition apart from lower contents of carotene (0.24–0.60 mg) and calcium (29–46 mg). The same applies to kohlrabi tubers, which in addition have lower protein (1.8 g) and fat (0.1 g) contents, and a lower energy value (125 kJ/100 g).

Description Very polymorphous, annual or biennial, erect herb, up to 1.5 m tall, glabrous, often much branched in upper part. Stem usually subterete, sometimes much thickened, pruinose. Leaves variable, lower ones usually petioled; leaf-blade lyrate or obovate, subentire or undulate, more or less deeply and irregularly lobed, very variable in shape, colour, size and thickness. Inflorescence racemiform or paniculiform, up to 1(–2) m long, racemes 20–40-flowered, lax, terminal; flowers rather large, pedicel up to 2 cm long, buds raised far above the expanded flowers; sepals 4, erect; petals 4, about twice as long as the sepals, oblong-spathulate, 1.5–2 cm long; stamens 6, erect. Fruit a stalked silique, cylindrical, 5–10 cm × 0.2–0.5 cm, with a tapering beak. Seed globose, 2–4 mm in diameter, grey-black to red-brown.

- Cv. group Brussels Sprouts: Biennial with simple erect stem up to 1 m tall. Axillary buds develop into compact miniature cabbage heads or sprouts, about 3 cm in diameter. On top of the stem is a rosette of leaves. Leaves generally petiolate; leaf-blade rather small, subcircular.
- Cv. groups of Kales: A very variable group of forms, morphologically most closely related to wild cabbage. Stem coarse, neither branched nor markedly thickened, 30–100 cm long. At the apex of the stem a rosette of generally oblong, sometimes red-coloured leaves occurs; sometimes the leaves are curled (caused by disproportionate rapid growth of leaf tissue along the margins). In borecole or curly kale the leaves are crinkled and more or less finely divided, often green or brownish-purple, and they are used as vegetable. Collards have smooth leaves, usually green; they are most important as forage in western Europe. Marrowstem kale has a succulent stem, up to 2 m tall, which is mainly used as forage in western Europe. Palmtree kale is up to 2 m tall, with a rosette of leaves at the apex; it is mainly used as an ornamental. Portuguese kale has leaves with succulent midribs which are used as a vegetable. Thousand-headed kale bears a whorl of young shoots at some distance above the soil, together more or less globular in outline; it is mainly used as forage.

Brassica oleracea L. cv. group Kohlrabi – habit.

- Cv. group Kohlrabi: Biennial in which secondary thickening of the short stem produces the spherical edible portion, 5–10 cm in diameter, green or purple. Leaves glaucous with slender petioles, arranged in a compressed spiral on the swollen stem.

Growth and development The seedling forms an often red-coloured hypocotyl, several centimetres long, two notched cotyledons and a taproot with lateral roots. The first true leaves are usually petiolate, but sessile in headed cabbage and cauliflower. Leaves are glabrous, coated with a layer of wax. After some time, typical deviations in growth occur depending on cultivar, e.g. extreme secondary growth in thickness of the stem in kohlrabi, head formation of the leaves in headed cabbages, miniature head formation of axillary buds in Brussels sprouts, metamorphosed inflorescences in cauliflower and broccoli. In temperate regions *B. oleracea* is usually biennial: vegetative growth during the first season, vernalization during winter, and flowering and fruiting during the second season. The flowers are insect-pollinated, especially by bees. The fruit (silique) reaches its maximum length 3–4 weeks after anthesis. When it is ripe, dehiscence takes place through the two valves breaking away from below upwards, leaving the seeds attached to the placentas.

The time taken for the swollen stem to develop in kohlrabi depends on the cultivar: from 4–6 weeks after planting for early cultivars, from 10–12 weeks for late cultivars.

Other botanical information The enormous variability of cultivated Brassicas and the uncertainty about their exact origin led to numerous classifications and a confusing botanical nomenclature. At present, the cultivated $2n = 18$ *Brassica* group is generally considered to belong to one species: *B. oleracea*, including e.g. white, red and savoy cabbage, cauliflower, broccoli, Brussels sprouts, kohlrabi and different kinds of kale. Usually those subunits are classified as botanical varieties and forms (e.g. white and red cabbage as var. *capitata* L., savoy cabbage as var. *sabauda* L.), but there is no general agreement. Below species level it seems better to classify directly into cultivar groups and cultivars.

Ecology Brussels sprouts and kales are the hardiest of the cole crops, withstanding temperatures of –10°C, but also high summer temperatures. The vernalization requirements for flower induction (varying periods at low temperatures, depending on the cultivar) are usually not met in tropical areas. Seed vernalization, however, is possible in certain kohlrabi cultivars. It involves storing germinated seed for 35–50 days at –1°C. Other kohlrabi cultivars lack a juvenile phase and premature bolting is a problem; it is probably caused by exposure of plants to temperatures below 10°C. High temperatures tend to affect the compactness of the axillary buds of Brussels sprouts, resulting in loose-leafed buds. In kohlrabi, high temperatures, as well as shade and ample nitrogen, favour the formation of elongated swollen stems.

These crops do not demand much from the soil. They are usually grown on light to medium-heavy soils. Optimum pH is 6.0–7.5.

Agronomy All cole crops are grown from seed. Propagation by cuttings is sometimes practised in tropical areas, as flowering does not occur. Brussels sprouts, kales and kohlrabi are usually sown on a seed-bed and transplanted when the seedlings are 3–5 cm tall. Steady growth is essential for Brussels sprouts and kohlrabi. A check in growth causes the swollen stems of kohlrabi to become fibrous, whereas too rapid growth causes them to crack and Brussels sprouts to become loose-leafed.

Diseases and pests are the same as those of other cole crops.

Brussels sprouts are normally harvested repeatedly, as the lower sprouts grow more rapidly. The growth of upper sprouts can be hastened by removing the main growing point. In kales, usually the complete rosette of leaves at the top of the stem is harvested, but sometimes individual leaves are picked. Kohlrabi should be harvested before the stems are full grown to avoid toughness. Usually the foliage is left on the swollen stem.

In temperate regions, yields vary between 5–10 t/ha for Brussels sprouts, 10–25 t/ha for kales, and 15–40 t/ha for kohlrabi. Seed yields of Brussels sprouts and kales are 300–1300 kg/ha.

Apart from being consumed fresh, these crops are also processed by canning and freezing in temperate regions.

Genetic resources and breeding Main germplasm collections of Brussels sprouts, kales and kohlrabi are maintained in European countries and the United States. Attempts are being made to breed annual cultivars to make seed production possible in tropical areas. Kales are the main source of genes conferring resistance to environmental stress.

Prospects With increasing standards of living, the importance of Brussels sprouts, kales and kohlrabi has been declining steadily in western countries. It is not expected that they will become important crops in South-East Asia, maybe with the exception of kohlrabi.

Literature |1| Brown, H.D. & Hutchinson, C.S., 1949. Vegetable science. Lippincott, Chicago, United States. pp. 287–413. |2| Dickson, M.H. & Wallace, D.H., 1986. Cabbage breeding. In: Bassett, M.J. (Editor): Breeding vegetable crops. Avi Publishing Company, Westport, Connecticut, United States. pp. 395–432. |3| George, R.A.T.,

1985. Vegetable seed production. Longman, New York, United States. 318 pp. |4| IBPGR, 1981. Genetic resources of cruciferous crops. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 48 pp. |5| Nieuwhof, M., 1969. Cole crops. Leonard Hill, London, United Kingdom. 353 pp. |6| Snogerup, S., 1980. The wild forms of the Brassica oleracea group (2n = 18) and their possible relations to the cultivated ones. In: Tsunoda, S., Hinata, K. & Gomez-Campo, C. (Editors): Brassica crops and wild allies: biology and breeding. Japan Scientific Societies Press, Tokyo, Japan. pp. 121–132.

P.C.M. Jansen, J.S. Siemonsma & J.O. Narciso

Brassica oleracea L. cv. groups Cauliflower & Broccoli

Cv. group names are proposed here.

CRUCIFERAE

$2n = 18$

Synonyms

- Cv. group Cauliflower. Synonyms: *B. oleracea* L. var. *botrytis* L. (1753), *B. cauliflora* Gars. (1764), *B. botrytis* (L.) Miller (1768).
- Cv. group Broccoli. Synonym: *B. oleracea* L. var. *italica* Plenck (1794).

Vernacular names

- Cv. group Cauliflower: Cauliflower (En). Chou fleur (Fr). Indonesia: kubis bunga, kol bunga, blumkol. Malaysia: kubis bunga. Papua New Guinea: koli flawa. Cambodia: phkaa spéi. Laos: kalampii dook. Thailand: kalam-dok. Vietnam: s[us]p l[ow], c[ar]i hoa.
- Cv. group Broccoli: Broccoli, sprouting broccoli, calabrese (En). Chou brocoli (Fr). Indonesia: brokoli. Papua New Guinea: brokoli. Thailand: brokkholi.

Origin and geographic distribution A remarkable diversity of cauliflower and broccoli-like vegetables exists in Italy; they probably evolved from germplasm introduced in Roman times from the eastern Mediterranean. During the last 400 years, white-headed cauliflowers spread from Italy to central and northern Europe, which became important secondary centres of diversity for the annual and biennial cauliflowers presently cultivated worldwide in temperate climates. Cauliflowers adapted to hot and humid tropical climates evolved in India during the last 200 years from biennial cauliflowers mainly of British origin. Broccolis with multiple green, purple or even white flowerheads (sprouting broccoli) became popular in northern Europe in the 18th Century. Broccoli with one main green head (calabrese) was introduced into the United States by Italian immigrants during the early 20th Century. From the United States it has spread to northern Europe, Japan and other regions in the last 50 years.

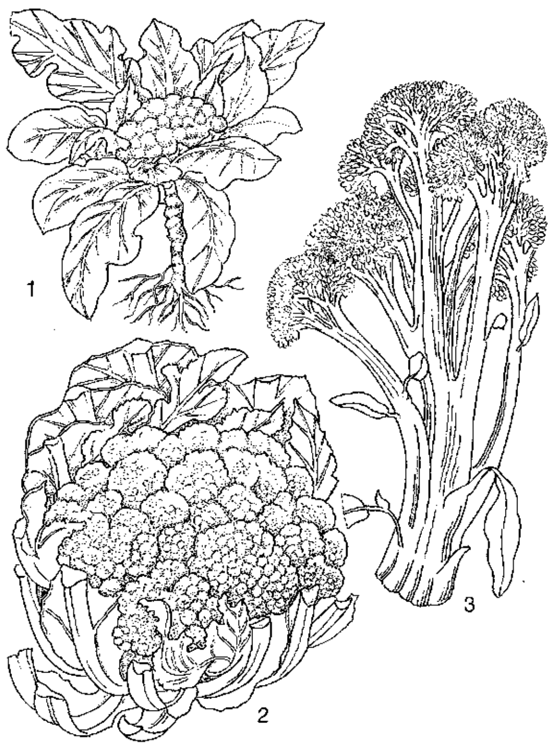
Uses Cauliflower and broccoli are grown for their large, edible, very young inflorescences. Cauliflower heads (curds) are mostly consumed as a cooked vegetable, sometimes cut into small pieces (florets) and used in salad mixes or in pickles. The flowerheads of broccoli and the fleshy upper portion of the stem are also consumed as a cooked vegetable. Broccoli, and to a lesser extent cauliflower, have become popular as a quick-frozen vegetable, particularly in the United States and Europe. Both are also processed in dried mixtures of soup vegetables.

Production and international trade Total world production of cauliflower is estimated at 5.5 million t per year from 410 000 ha. Major cauliflower producing countries are: India 95 000 ha, China 90 000 ha, France 45 000 ha, United States and Mexico 40 000 ha, Italy 23 000 ha, United Kingdom 21 000 ha, Spain 13 000 ha, Japan 11 000 ha, Taiwan 6100 ha. In South-East Asia cauliflower is still generally a minor crop and mostly restricted to the cool dry season or to the highlands: Thailand 4000 ha, Indonesia 2000–3000 ha, Vietnam 1500 ha. World statistics on broccoli production are incomplete and often mixed with cauliflower data. The most important broccoli producing countries are: United States 26 000 ha, Taiwan 7200 ha, United Kingdom 5000 ha, Italy 4000 ha, Spain 1500 ha. In Asia all cauliflower and broccoli are produced for local and urban markets.

Properties The nutritional value of cauliflower is good, but that of broccoli is better due to higher carotene, vitamin C and calcium contents. Per 100 g fresh edible portion, cauliflower curd contains on average: water 88 g, protein 4 g, fat 0.3 g, carbohydrates 6 g, fibre 1.5 g, Ca 25 mg, K 325 mg, carotene 200 mg, vitamin C 40 mg. Values are similar for broccoli except for Ca 150 mg, carotene 800 mg and vitamin C 100 mg. The energy value is 245 kJ/100 g.

The 1000-seed weight for cauliflower and broccoli is 2.5–4 g.

Description Cauliflower is a biennial or annual herb, 50–80 cm tall at the mature vegetative stage, 90–150 cm when flowering. Root system strongly ramified, concentrated in the top 30 cm of the soil, some thicker lateral roots penetrating into deeper layers. Stem unbranched, 20–30 cm



Brassica oleracea L. cv. groups Cauliflower & Broccoli – 1, habit (cauliflower); 2, flower head (cauliflower); 3, flower head (sprouting broccoli).

long, thickening upwards. Leaves in a rosette (frame) of 15–25 large, oblong, more or less erect leaves surrounding the compact terminal flower-head (curd); usually no lateral buds develop in the leaf axils; leaves almost sessile, glabrous, coated with a layer of wax; leaf-blade grey- to blue-green with whitish main and lateral veins, in shape varying from short and wide (40–50 cm × 30–40 cm) with curly edges to long and narrow (70–80 cm × 20–30 cm) with smooth edges. The curd consists of a dome of proliferated floral meristems, white to cream or yellow, on numerous short and fleshy peduncles. The curd varies from a rather loose to a very solid structure, a flattish to a deep globular shape, 10–40 cm in diameter. Young leaves may envelop the curd until a far advanced stage of development. Bolting cauliflower plants often have several flower stalks. Inflorescence a raceme, 40–70 cm long, extending from the terminal point of the main stem; pedicel 1.5–2 cm long; flowers tetramerous, bisexual; sepals erect, green; petals spathulate, 25 mm × 10 mm, yellow, sometimes white; stamens 6, 2 short and 4 long; ovary superior with false septum and 2 rows of campylotropous ovules; nectaries 2, situated between the base of the ovary and the short stamens. Fruit a silique, 0.5 cm × 5–10 cm, containing 10–30 seeds. Seed globose, 2–4 mm in diameter, brown. Germination is epigeal. Seedlings have a thin taproot and cordate cotyledons; the first true leaves are ovate with a lobed petiole.

Broccoli (the single-headed type or calabrese) differs from cauliflower in the following aspects: leaves are more divided and petiolate; the main head consists of clusters of fully differentiated flower buds, green to purple, less densely arranged and with longer peduncles; axillary shoots with smaller flower heads usually develop after removal of the dominant terminal shoot. The flower head is fully exposed from an early stage of development. Broccoli plants carry inflorescences from lateral branches too.

Sprouting broccoli bears many, more or less uniform, relatively small flowerheads instead of one large head as in the calabrese type.

Growth and development Cauliflower and broccoli seed (6% moisture content) will remain viable for at least 4–6 years when stored dry at temperatures below 18°C. Seeds germinate within 3–6 days and seedlings have 7–9 true leaves within 30–40 days at > 20°C average daily temperatures.

Differentiation of floral primordia in cauliflower can only start at the end of the juvenile phase, when plants have 12–15 leaves for early types to more than 25–30 leaves for late biennial types. Good curd formation requires a subsequent period of 20–30 days at slightly lower temperatures (18–20°C) for very early types to < 15°C for late types. Higher than optimum temperatures during this period will cause delayed and abnormal curd formation, except for the heat-tolerant early cauliflowers developed in India.

Vernalization requirements of most broccoli types are similar to those of cauliflower, except that broccolis are probably also devernalized by short photoperiods.

Heads of annual cauliflower and broccoli types are ready for harvesting 75–150 days after sowing, depending on cultivar and climate.

Very soon after the optimum harvesting date, curds of cauliflower plants start to enlarge, become loose, the peduncles lengthen and turn green and the floral meristems develop into inflorescences. Particularly in the modern cultivars with very firm and dense curds, only part of the floral meristems will develop into flowers, with the rest aborting and becoming a substrate for pathogenic fungi under humid conditions. In broccoli the head is already a mass of fully developed flower buds and normally very little abortion takes place.

Flowering starts at the base of the racemes and continues for about one month in cauliflower and for 20–25 days in broccoli plants. Sporophytic self-incompatibility (1-locus system with multiple alleles) precludes self-fertilization in most cauliflower and broccoli, except the annual cauliflower types developed in northern Europe which are selected for self-fertility (absence of S-alleles). Insects, especially bees, effect pollination. Seeds are mature 45–50 days after anthesis.

Other botanical information Although much confusion exists regarding classification and nomenclature of cauliflowers and broccolis, the two cv. groups can easily be distinguished on the basis of the marketable product. In cv. group Cauliflower the head is a mass of proliferated floral meristems in which no individual flower buds can be distinguished. In cv. group Broccoli the head or heads (sprouts) are a mass of fully differentiated, clearly visible flower buds.

Cultivars with intermediate characteristics are hybrids between the two cv. groups and can best be classified in separate cv. groups, e.g. cv. group Hybrid Cauliflower or cv. group Hybrid Broccoli, depending on its most prominent characteristic. The vernacular nomenclature of cauliflowers and broccolis cannot always be trusted.

Present-day cauliflower cultivars have evolved, often by re-combination, from a number of types which can be grouped according to their phylogeny:

- Italian: very diverse annuals and biennials, some with peculiar curd formations and colours; e.g. 'Jezi', 'Naples', 'Autumn Giant', 'Fano', 'Romanesco', 'Flora Blanca'.
- Northern European annuals: early summer to autumn types developed over the past 400 years from material of Italian or eastern Mediterranean origin; e.g. 'Erfurter', 'Snowball', 'Mechelse', 'Alpha', 'Danish Perfection', 'Giant', 'Le Cerf'.
- North-western European biennials: overwintering and winter-hardy types developed in maritime climates over the past 300 years from Italian material; e.g. 'Roscoff', 'St. Malo', 'Old English', 'Cornish', 'Angers', 'Walcheren'.
- Australian: late-maturing annuals developed from European annual and biennial types introduced some 200 years ago; e.g. 'Barrier Reef', 'Snowy River', 'Kangaroo'.
- Asian: early maturing annuals adapted to hot and humid climates, developed in India since the early 19th Century from English winter types; e.g. 'Patna', 'Benaras', 'Early Market'. This material was later also used in Brazil, Hawaii, Japan and Taiwan to develop cultivars adapted to hot climates. The main drawback, however, is the formation of rather loose, uneven and yellowish-coloured curds.

In broccoli the main distinction is between:

- Sprouting types: multi-branched with relatively small heads with green, purple or even white flower buds; e.g. 'Purple Sprouting'.
- Heading types or Calabrese: a mass of flower buds in one large main head on a short central stalk; smaller heads may develop on lateral branches after removal of the main head; the colour of the head can be dark purple (e.g. 'Purple Cape', 'Sicilian Purple'), brownish (e.g. 'Brown Headed'), yellowish-green (e.g. 'Sulphur Coloured'), dark green (e.g. 'Chartreuse'), or white.

In Indonesia and other South-East Asian countries, seed of broccoli is mostly bought from international seed companies. However, cauliflower is mostly grown from seed produced by the farmers. There are many farmers' selections, probably originating from early cauliflower introductions from Europe. The local cauliflower type grown in Indonesia in the highlands above 1000 m is early-maturing with loose curd, tasty but with an inferior external quality. Farmers select the best curds from their fields, replant them under a plastic cover, and remove with a knife part of the curd in order to stimulate flowering.

The open-pollinated cauliflower cultivars are increasingly being replaced by F_1 hybrids. All present-day broccoli cultivars are F_1 hybrids. Japanese breeders were the first to start developing F_1 hybrids in annual cauliflower and broccoli some 30 years ago.

Ecology Most cauliflower and broccoli cultivars only produce heads of good quality when grown at average daily temperatures of 15–20°C and a diurnal variation of at least 5°C. In tropical regions such conditions are only found at elevations above 800 m. The heat-tolerant Asian cauliflowers are more adapted to tropical lowland conditions, but curd quality is generally inferior.

A regular supply of water is required throughout the growing season, but the heads of cauliflower and broccoli are easily affected by fungal rots when continuously exposed to wet conditions. The mature plant stage and harvesting should, therefore, be planned as much as possible outside the rainy season and overhead irrigation should be avoided. For successful seed production a fairly cool and dry climate is also a prerequisite. Soils should be well-drained and fertile, have good moisture retaining capacity, and high organic matter content; optimum pH is 6.5–7.5.

Propagation and planting Dormancy of freshly harvested seed can be reduced by overnight soaking and rinsing in water; it also disappears after 3–4 months of storage. Seeds are sown on seed-beds, peat blocks or trays; young seedlings may have to be shaded to prevent sun scorching. Seed requirements are 300–350 g/ha. Transplanting to the field should be done when seedlings have 7–9 true leaves, 30–50 days after sowing. Plant densities for cauliflower are 20 000–35 000 plants/ha; for broccoli similar or somewhat higher densities are applied.

Vegetative propagation of broccoli plants is possible by rooting and transplanting of lateral shoots. In cauliflower lateral shoots are not available, but propagation through tissue culture from young floral meristems is easy to realize. This is often practised in breeding programmes to maintain selected plants.

Husbandry Soil preparation includes deep digging, mixing with compost or stable manure (20 t/ha), followed by fine tillage. NPK fertilizers – type and rates depending on soil type, mineral reserves in the soil and expected yields – are applied before planting; another two or three N fertilizer dressings are applied later to stimulate good head formation.

Nitrogen deficiency at the early growth stage will cause 'buttoning': stunted plants with reduced leaf and head development. Cauliflower and broccoli have a high demand for Mg, Bo and Mo and applications of dolomitic limestone, borax and ammonium molybdate may be necessary to prevent physiological disorders such as plants without a heart and browning of the head. Deficiencies occur earlier on acid soils.

The young crop should be kept free of weeds. Mulching, e.g. with rice straw, is beneficial to growth as it retains moisture, keeps soil temperatures down and suppresses weeds.

Growth of the plants should be regular and undisturbed. Sudden increases in temperature or water stress may cause bracting (green leaves) and riciness (extended young flower stalks) of cauliflower curds, irregular head formation and premature flowering in broccoli. Maturing cauliflower curds must be protected from direct sunlight by covering with broken off leaves to prevent them from turning yellow and/or pink. Many modern cultivars are self-protecting, i.e. inner leaves wrap tightly around the curd.

Diseases and pests Diseases and pests are similar to those of cabbage in tropical regions. For important diseases such as fusarium yellows (*Fusarium oxysporum* f.sp. *conglutinans*), downy mildew on leaves and heads (*Peronospora parasitica*), black rot (*Xanthomonas campestris* pv *campestris*) and clubroot (*Plasmodiophora brassicae*), resistance or field tolerance have been found in cauliflower and broccoli accessions, but the majority of present-day cultivars are still susceptible. Other diseases causing problems are the two seed-borne diseases black leg (*Phoma lingam* = *Leptosphaeria maculans*) and *Alternaria* blight (*A. brassicae*), and powdery mildew (*Erysiphe polygoni*), damping-off (*Pythium ultimum*), stem rot (*Rhizoctonia solani*), bacterial soft rot (*Erwinia carotovora*) as storage disease, and cauliflower mosaic virus (CauMV). Root knot nematodes (*Meloidogyne* spp.) can be a serious problem and should be avoided by proper crop rotation.

Important pests are diamond-back moth (*Plutella xylostella*), cutworm (*Agrotis* spp. and *Spodoptora littoralis*), cabbage moth (*Crocidolomia binotalis*), cabbage butterfly (*Pieris canidia*) and aphids (*Aphis* spp. and *Brevicoryne brassicae*), the vectors of CauMV. Diamond-back moth is extremely noxious because the pupae hide in the heads or curds and removal is virtually impossible. Methods of integrated pest management as applied to cabbage (with parasitoids, sex pheromones, trap plants and very restricted chemical control) can also be effective in cauliflower and broccoli.

Harvesting Annual cauliflower and broccoli are ready for harvesting 60–120 days after transplanting; some early heat-tolerant cultivars, mainly F_1 hybrids, even within 45–55 days in tropical regions. Harvesting takes place over a period of 1–2 weeks.

Cauliflower heads are cut with sufficient trimmed leaves still attached to protect the curds during packing and transport. Broccoli heads are harvested with 10–15 cm of stem, without leaves.

Yield Cauliflower yields can attain 12–30 t/ha and broccoli yields 4–10 t/ha; in the tropics highest yields are obtained above 1000 m. Seed yields are 200–600 kg/ha in temperate climates.

Handling after harvest Cauliflower and broccoli heads will deteriorate quickly unless cooled soon after harvesting. Cauliflower curds can be stored for about 3 weeks at 1°C and 95% relative humidity, but storage life for broccoli is much shorter and heads are usually wrapped in polythene film to prevent rapid desiccation and yellowing.

Genetic resources Germplasm collections of cauliflower and broccoli are available in several research centres, particularly in Europe, the United States, India and Japan. However, within the main Italian and secondary central and northern European gene centre, every effort should be made to preserve the genetic variability for future breeding purposes. Genetic erosion also is a real danger in all South-East Asian countries, because local selections are being replaced by commercial cultivars from seed companies. Many old cultivars have already disappeared, representing considerable genetic erosion and probable loss of unique genes. The single-headed broccoli (calabrese) is particularly very narrow-based genetically .

Breeding F_1 hybrids, based on single crosses between inbred lines, are now the main goal of most breeding programmes in cauliflower and broccoli. Seed production depends on the system of sporophytic self-incompatibility present in most types. S-alleles have been re-introduced in the self-compatible annual cauliflowers of northern Europe. Self-fertilization, necessary to develop homozygous inbred lines, is effected by bud pollination or treatment with CO_2 (2–6%) before bee pollination, to temporarily break the self-incompatibility. Inbred lines have also been developed from di-haploid plants regenerated from anther or microspore cultures.

The main breeding objectives include: head shape, size, firmness, weight, colour (pure white in cauliflower, dark green in broccoli), no physiological disorders, yield, earliness, standing ability, heat tolerance, resistance to diseases and pests.

Prospects The importance of cauliflower and broccoli is likely to increase further in South-East Asia. Heat-tolerant cultivars enable cultivation at low altitudes, but market gardening will continue to prevail in the highlands because of higher yields, better head quality and fewer disease and pest problems. Considerable progress is being made with effective methods of integrated pest management, as in cabbage, and this will reduce pesticide use. Cultivars resistant to fusarium, black rot and downy mildew will gradually become available, but durable resistance to clubroot is very hard to realize.

The development of DNA markers for more precise indirect screening for resistance to diseases, pests and other important traits can increase breeding efficiency. Cytoplasmic male sterility might, in the long run, replace self-incompatibility as a more reliable technique for hybrid seed production.

Literature |1| Crisp, P., 1982. The use of an evolutionary scheme for cauliflower in the screening of genetic resources. Euphytica 31: 725–734. |2| Crisp, P., Crute, I.R. et al., 1989. The exploitation of genetic resources of Brassica oleracea in breeding for resistance to clubroot (Plasmodiophora brassicae). Euphytica 42: 215–226. |3| Gray, A.R., 1982. Taxonomy and evolution of broccoli (Brassica oleracea var. italica). Economic Botany 36: 397–410. |4| Gray, A.R. & Crisp, P., 1977. Breeding systems, taxonomy and breeding strategy in cauliflower (Brassica oleracea var. botrytis). Euphytica 26: 369–375. |5| Nieuwhof, M., 1969. Cole Crops. Leonard Hill, London, United Kingdom. 353 pp. |6| Shinohara, S. (Editor), 1984. Vegetable seed production technology of Japan. Shinohara's Authorized Agricultural Consulting Engineer Office, Tokyo, Japan. Vol. 1. pp. 55–81. |7| Swarup, V. & Chatterjee, S.S., 1972. Origin and genetic improvement of Indian cauliflower. Economic Botany 26: 381–392. |8| Whitwell, J.D., Jones, G.L. & Williams, J.B., 1982. Cauliflowers. ADAS/MAFF Reference Book 131, Growers Books, London, United Kingdom. 87 pp.

H.A.M. van der Vossen

Brassica oleracea L. cv. group Chinese Kale

Cv. group name is proposed here.

CRUCIFERAE

$2n = 18$

Synonyms *B. alboglabra* L.H. Bailey (1922), *B. oleracea* L. var. *alboglabra* (L.H. Bailey) Musil (1948).

Vernacular names Chinese kale (En). Broccoli de Chine (Fr). Indonesia: kailan. Malaysia: kailan. Cambodia: spéi sâà. Thailand: phakkhana.

Origin and geographic distribution Whereas most forms of *B. oleracea* evolved in Europe, Chinese kale is a cultigen native to southern and central China. It is now widely cultivated and popular in South-East Asia.

Uses Chinese kale is commonly grown for its stem, young leaves and young inflorescences which are consumed cooked or fried, sometimes raw. It can be used from the young vegetative stage up to the early flowering stage. In the latter case, thick stems have developed which must be peeled before cooking. The older leaves are rather tough in texture and strong in taste.

Production and international trade Few statistics are available, but Chinese kale ranks among the ten most important market garden vegetables in some South-East Asian countries such as Thailand (6700 ha in 1988). It is also widely grown in home gardens and market gardens around cities. Its short growing period hampers correct registration of acreages and production. In Indonesia, Chinese kale is still of minor but increasing importance.

Properties The edible parts of Chinese kale have a high content of essential micronutrients. Per 100 g edible portion it contains: vitamin A 7540 IU, vitamin C 115 mg, Ca 62 mg, Fe 2.2 mg. The dry matter content varies between 10–14%, depending on the harvesting stage. The 1000-seed weight is about 3 g.

Description Annual herb, up to 40 cm tall during the vegetative stage, up to 1(–2) m tall at the end of flowering, all vegetative parts glabrous and glaucous. Taproot strongly branched. Stem single, narrow-branching or forking in upper part. Leaves alternate, thick, firm, petiolate; leafblades ovate to orbicular-ovate, margin irregularly dentate and often undulate, characteristically auriculate at base or on the petiole; basal leaves smaller; upper leaves narrowly oblong, subsessile, without auricles. Inflorescence a terminal or axillary raceme, 30–40 cm long; pedicel 1–2 cm long; flowers usually white, sometimes yellow, rarely red, 2–3 cm in diameter, 4-merous but with 6 (tetradynamous) stamens. Fruit a silique, 3–9 cm long, with a conical beak. Seed subglobose, 2–3 mm in diameter, brown to black, minutely foveolate (pitted).

Brassica oleracea L. cv. group Chinese Kale – flowering shoot.

Growth and development Seeds germinate 3–5 days after sowing. Vegetative development is slow during the first two weeks, but then accelerates. Flowering usually starts 55–80 days after sowing depending on cultivar and cultural practices. Chinese kale is cross-pollinated by insects. Seeds mature in 50–60 days from pollination.

Other botanical information Chinese kale is only known in a cultivated state and no wild relatives are known. Sometimes it is considered as a distinct species (*B. alboglabra*), more often as a variety (var. *alboglabra*) of *B. oleracea*. As it is only known cultivated, it seems more appropriate to classify it as a cultivar group within *B. oleracea*. It is not clear to which other forms within *B. oleracea* it has most affinity: to the European kales or to the cauliflower/broccoli group which shows a tendency towards annuality.

There are numerous landraces in China and South-East Asia. Some cultivars are available from Chinese, Taiwanese and Thai seed companies. Cultivars are distinguished on the basis of flower colour, leaf shape, leaf texture and colour, internode length, and usage.

Ecology Optimum temperatures range from 25–30°C for germination, and from 18–28°C for vigorous growth. Low temperatures promote early flowering and are also necessary for complete floral development. Chinese kale is frost-tolerant. It does well under sunny conditions in moist, well-drained soils. Chinese kale can be grown year-round in the tropics.

Propagation and planting Chinese kale is propagated by seed. The most common practice is sowing by broadcasting at a rate of 3–6 g/m^2 (30–60 kg/ha) for the harvest of very young plants. When only plants in the early blooming stage are preferred, it is more economical to sow on nursery beds and to transplant 3-week-old seedlings to the field, in order to avoid long field occupancy. The seed requirement is then only 3 kg/ha.

Husbandry In Thailand, where consumers prefer Chinese kale in a young growth stage, farmers generally broadcast the seed on well-prepared land. On poor soils, the application of 10–20 t/ha of organic manure and 250 kg/ha of NPK (15–15–15) is recommended. The seedlings are thinned 14 days after sowing. The second thinning, performed 3–4 weeks after sowing when the plants have formed about 5 true leaves and the stem is 0.5 cm in diameter is also the first harvest. Thinning is repeated regularly until the plant spacing becomes approximately 30 cm × 30 cm. Plants are then left to grow until the final mature harvest. Top dressings of 20 kg/ha of a nitrogen fertilizer are recommended every 10 days after the first thinning.

Diseases and pests A serious disease is damping-off (*Pythium* sp.), which can be controlled to some extent by good drainage, by avoiding over-dense sowing, and with fungicides such as dithiocarbamates. Downy mildew (*Peronospora parasitica*) is another serious disease during the damp and cool season.
Insects are the most serious problem for the Chinese kale grower. Flea beetles, diamond-back moth, borers and cabbage looper are the most harmful, besides aphids, grass hoppers and crickets. Spraying insecticides up to twice a week is generally practised, causing problems with harmful residues due to the high harvest frequency. In Thailand whole fields of Chinese kale are sometimes netted against diamond-back moth. The same IPM technology as developed for cabbage may be applied.

Harvesting Harvesting can be done at any growth stage, from 3 weeks after sowing up to the early flowering stage. During the early stages, the crop is usually harvested by thinning, whereas at the mature stage, the plants are cut at ground level. Another method is harvesting by repeated cuttings every 3 weeks (ratooning). In this case, wide spacing is needed (at least 30 cm × 30 cm) and cutting must be practised in such a way that at least 2 leaves and buds are left for regrowth.

Yield Yield varies from 0.8–4 kg/m^2 depending on the harvesting method.

Handling after harvest Chinese kale can be kept fresh for some days under moist, cool storage. In markets and shops it is regularly sprinkled with water to maintain a fresh appearance. It is tied in bunches and sold by unit of money or by weight.

Genetic resources Small germplasm collections of Chinese kale are kept at various institutions in South-East Asia such as national gene banks, universities and seed companies. Despite its wide distribution, there appears to be relatively little diversity of type, probably because of the absence of gene flow from other cole crops. Supplementation of existing collections is recommended, particularly with Chinese germplasm.

Breeding The main breeding objective is earliness. Chinese kale is more heat tolerant than its *B. oleracea* relatives, and is used to improve this character in broccoli.

Prospects Chinese kale is recognized as a very productive crop for the tropics, very suitable as a cheap green for large city markets. Research should focus on optimizing cultural practices, in particular pest control with less harmful residues. Resistance to diamond-back moth and the development of integrated pest management (IPM) must be further pursued.

Literature |1| Bailey, L.H., 1922, 1930. The cultivated Brassicas. Brassica alboglabra. Gentes Herbarum 1(2): 79–81, 2(5): 233–234. |2| Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 193–195. |3| IBPGR, 1981. Genetic resources of cruciferous crops. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 48 pp. |4| Phillipps, K. & Dahlen, M., 1985. A popular guide to Chinese vegetables. MPH Bookstores, Singapore. p. 21. |5| Thuanthavee, M. & Panyatona, S., 1982. Vegetable garden. Agri Book Group, Bangkok, Thailand. pp. 118–121.

C. Sagwansupyakorn

Brassica oleracea L. cv. groups White Headed Cabbage Red Headed Cabbage Savoy Headed Cabbage

Cv. group names are proposed here.
CRUCIFERAE
$2n = 18$

Synonyms
- Cv. group White Headed Cabbage: *B. oleracea* L. var. *capitata* L. f. *alba* DC. sensu Nieuwhof (1969), *B. oleracea* L. ssp. *oleracea* convar. *capitata* (L.) Alef. var. *capitata* L. f. *alba* DC. sensu Hegi (1986).
- Cv. group Red Headed Cabbage: *B. oleracea* L. var. *capitata* L. f. *rubra* (L.) Thell. sensu Nieuwhof (1969), *B. oleracea* L. ssp. *oleracea* convar. *capitata* (L.) Alef. var. *capitata* L. f. *rubra* (L.) Thell. sensu Hegi (1986).
- Cv. group Savoy Headed Cabbage: *B. oleracea* L. var. *sabauda* L. sensu Nieuwhof (1969), *B. oleracea* L. ssp. *oleracea* convar. *capitata* (L.) Alef. var. *sabauda* L. sensu Hegi (1986).

Vernacular names Headed cabbage (white, red or savoy), cabbage (white, red or savoy) (En). Chou cabus (Fr). Indonesia: kol, kobis, kubis.

Malaysia: kubis. Papua New Guinea: kapis. Philippines: repolyo (Tagalog). Cambodia: spéi k'daôb. Laos: kalampii. Thailand: kalam-pli. Vietnam: c[ar]i b[aws]p.

Origin and geographic distribution Headed cabbage evolved in north-western Europe during the early Middle Ages from leafy unbranched and thin-stemmed kales (often classified as *B. oleracea* L. var. *acephala* DC.), which spread in Roman times from the Mediterranean area, where *B. oleracea* var. *sylvestris* L. and other related species occur naturally in coastal areas. Whereas the primitive types were primarily originally cultivated for medicinal purposes, headed cabbage had become one of the most important vegetables in 16th Century Europe. From then onwards cabbage was introduced worldwide, but in tropical and subtropical areas commercial cultivation is still mostly restricted to the cooler climates of the highlands or to the mild cool seasons at higher latitudes.

Uses In tropical Asia the importance of cabbage, mainly early maturing white cabbage with firm and round to flat heads (1–2 kg), is rapidly increasing. It can be fairly easily produced in large quantities, transported over great distances without much damage and stored for several weeks. It has partly replaced the more perishable leafy vegetables, particularly in city markets. Cabbage is usually consumed as a cooked or fried vegetable, sometimes pickled or preserved by steaming and drying. It is often eaten fresh as an ingredient of coleslaw (a salad made of raw sliced or chopped cabbage) and mixed salads. Late maturing and large-headed (3–5 kg) cultivars are processed into sauerkraut. The prominence of white cabbage as a vegetable is gradually declining in western Europe.

Production and international trade Total area annually planted with cabbage worldwide is at least 800 000 ha: 200 000 ha in the former Soviet Union, 180 000 in eastern Europe, the Balkans and Middle East, 40 000 ha in western Europe, 100000 ha in the Americas and 280 000 ha in Asia (excluding China).

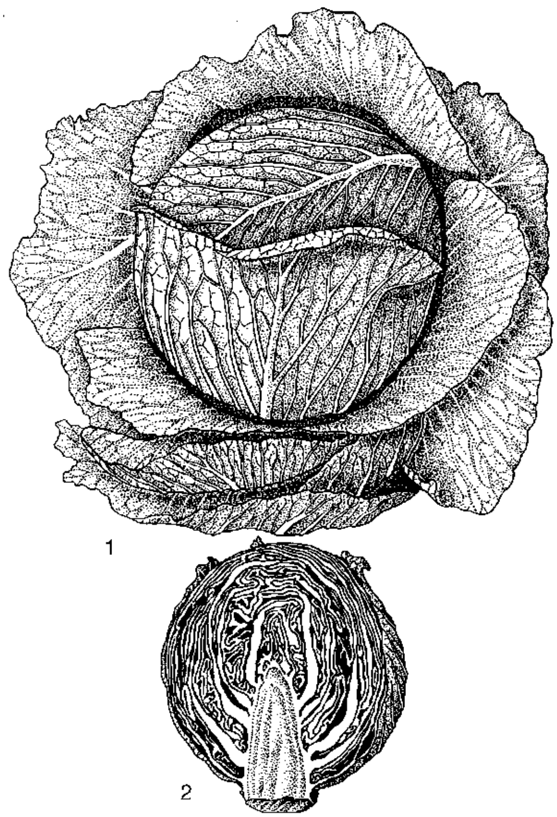
In Indonesia the area of white cabbage increased from 24 000 ha in 1975 to 41 000 in 1990 with a total production of 820 000 t. Thailand has about 7000 ha, the Philippines 6600 ha, Malaysia 1000 ha. White cabbage is also important in India (83 000 ha), Japan (42 000 ha), South Korea (41 000 ha) and Taiwan (10 000 ha).

Almost all white cabbage in Asia is produced for local (urban) markets. Singapore imports annually some 16000 t white cabbage from Indonesia, mainly from the Karo highlands in northern Sumatra. Singapore is also supplied from the Cameron highlands in Malaysia.

Properties White cabbage has a good nutritional value, although less than many green leafy vegetables. Per 100 g fresh edible portion it contains on average: water 91 g, protein 1.6 g, carbohydrates 6 g, fibre 0.8 g, Ca 55 mg, Fe 0.8 mg, vitamin C 50 mg. Dry matter content is 7% for most white cabbage grown in Asia, but is 10–11% in long-storage types of north-western Europe.

All *Brassica* L. crops contain glucosinolates which in crushed leaves are broken down by the enzyme myrosinase to give bitter-tasting, antimicrobial but also goitrogenic substances. In white cabbage glucosinolate content is very low (100 mg per 100 g) as a result of centuries of selection against bitter-tasting plants. The 1000-seed weight is 3–5 g.

Description Biennial herb, 40–60 cm tall at the mature vegetative stage, 150–200 cm tall when flowering in the second year. Mature plants have



Brassica oleracea L. cv. group White Headed Cabbage – 1, habit; 2, head (longitudinal section).

a strongly ramified system of thin roots, 90% in the upper 20–30 cm of the soil but some laterals penetrating downward to 1.5–2 m depth. Stem unbranched, 20–30 cm long, gradually thickening upward. Basal leaves in a rosette of 7–15 sessile outer leaves, each 25–35 cm × 20–30 cm; upper leaves in a compact flattened globose to ellipsoid head, 10–30 cm in diameter, formed by a great number of overlapping fleshy leaves around the single growing point; leaves glabrous, coated with a layer of wax, grey- to blue-green in the rosette and light-green to creamy-white inside the head (white headed cabbage); leaves red-purple in red headed cabbage, green to yellow-green and puckered in savoy headed cabbage. Inflorescence a 50–100 cm long raceme without bracts on the main stem and on axillary branches of bolted plants; pedicel 1.5–2 cm long; flowers tetramerous, bisexual; sepals erect, light-green; petals spathulate, 25 mm × 10 mm, yellow; stamens 6, 2 short and 4 long; ovary superior with false septum and 2 rows of campylotropous ovules; nectaries 2, situated between the base of the ovary and the short stamens. Fruit a silique, 5–10 cm × 0.5 cm, containing 10–30 seeds. Seed globose, 2–4 mm in diameter, brown. Germination is epigeal. Seedlings have a thin taproot and cordate cotyledons; the first true leaves are ovate with a lobed petiole.

Growth and development Seeds germinate within 3–6 days and seedlings have 4 true leaves 4–5 weeks after sowing at 15–20°C average daily temperatures. The first 7–15 leaves expand and unfold to form a rosette, commonly called the frame. Subsequent leaves only partly unfold, forming the shell of the head; the growing point increases in size, the stem thickens and the head is filled out with fleshy leaves. The head is solid and ready for harvesting 80–120 days after germination, depending on genotype and climate.

Most cabbage types require 6–8 weeks exposure to temperatures below 10°C for flower initiation and bolting. The main stem increases in length rapidly, causing the head to burst, and branches into a number of racemes. Flowering starts at the base of the racemes, 2–3 months after the first sign of bolting and continues for 4–5 weeks. Sporophytic self-incompatibility (1-locus system with multiple alleles) precludes natural self-fertilization. Insects, especially bees, effect cross-pollination. Seeds are mature 8–10 weeks after anthesis.

Other botanical information Several hundreds of cultivars of white cabbage are grown worldwide. In the market gardens of tropical Asia early-maturing compact and round- or flat-headed F_1 hybrids have almost completely replaced the open-pollinated cultivars such as 'Golden Acre', 'Copenhagen Market', 'Glory of Enkhuizen' and the flat-headed 'Drumhead'. F_1 hybrids are predominantly of Japanese origin: 'Green Boy' (='Gloria Osena'), 'Titan', 'Green Coronet', 'Summer Autumn', 'F_1 KK', 'F_1 KY', etc. Seeds of all these cultivars are imported from temperate regions.

'Yoshin' and 'Shanghai' are early-bolting Indonesian cultivars, seed of which can be produced locally on Java. These cabbages are sweet-tasting, but the heads are too loose for market gardening and long-distance transport.

Red cabbage and savoy cabbage are not very common in South-East Asia, and of economic importance mainly in Europe and America.

Ecology Cabbage grows best at average daily temperatures of 15–20°C and a diurnal variation of at least 5°C. In tropical regions these conditions are only met in highlands above 800 m. At temperatures in excess of 25°C young plants still grow well, but subsequent head formation will be retarded. Some Japanese F_1 hybrids are more heat-tolerant, but even these do not perform so well under tropical lowland conditions.

Most cabbage cultivars are daylength neutral and flower initiation is mainly induced by low temperatures. Half-grown cabbage plants can even withstand short spells of frost (−5°C).

Soils should be well-drained and fertile, having good moisture retaining capacity, high organic matter content and a pH of 6.5–7.5. Because of its shallow root system, cabbage needs a regular supply of water throughout the growing season either by rain or irrigation. Evapotranspiration of a fully-grown cabbage field can reach 4 mm per day.

Propagation and planting Dry cabbage seed (6% moisture content) will remain viable for at least 4–6 years when stored dry at temperatures below 18°C. Freshly harvested seed sometimes gives poor germination. Soaking overnight and rinsing with water overcomes this. After 3–4 months storage dormancy disappears. Seeds are sown on seed-beds, in pots or in trays; young seedlings may require protection from excessive sunshine by light shading. About 300 g seed and about 200 m² of seed-bed are required for 1 ha of cabbage. Transplanting to the field takes place 4–5 weeks later, when the seedlings have 4–6 true leaves. Plant densities of 30 000–50 000 plants per ha are usually applied and spacing is 40–50 cm × 55–60 cm. Head size can be largely regulated by adjusting plant density.

Lateral shoots from decapitated stumps can be rooted and transplanted. This method of vegetative propagation is practised in breeding programmes to maintain selected plants. A tradition on Java of multiplying some old loose-headed varieties (e.g. 'Wonosobo' and 'Argalinga') by cutting, has virtually disappeared.

Husbandry Cabbage crops are often grown in rotation with maize, rice, potato, legumes and tobacco. Soil preparation includes deep digging, mixing with compost or stable manure (20–50 t/ha), followed by fine tillage. Before planting NPK fertilizer is applied and for good vegetative growth dressings with N fertilizer are given when head formation starts. Type and quantities depend on soil type, initial nutrient reserves in the soil and yield level. The uptake and removal of nutrients is very high. A cabbage crop with a yield of 25 t/ha absorbs approximately 140 kg N, 40 kg P, and 180 kg K. Growing cabbage on ridges during the wet season improves drainage. The crop should be kept free of weeds, especially in the first month after transplanting. Mulching with rice straw is beneficial to growth.

Diseases and pests The most important diseases in tropical areas are: grey leaf mould (*Alternaria brassicae*) and downy mildew (*Peronospora parasitica*), which can be controlled by fungicides and selection of tolerant cultivars; bacterial soft rot (*Erwinia carotovora*) under hot and humid conditions; black rot (*Xanthomonas campestris* pv *campestris*), controlled by disease-free seeds and seedlings (some cultivars have a good level of tolerance); clubroot (*Plasmodiophora brassicae*), prevented by wide crop rotation, by liming and cultivation on soils with $pH > 7$, and by stimulating antagonistic fungi in the soil (promising experimental results in West Java with *Mortierella* spp.). Clubroot is spreading fast during the last decades and has become the most detrimental disease in many highland areas. Cultivars with durable resistance to clubroot are not yet available. Other diseases: ring-spot (*Mycosphaerella brassicicola*), cabbage yellows (*Fusarium oxysporum*), which can be controlled by crop rotation and resistant cultivars; cauliflower and turnip mosaic virus, which can be prevented by control of the aphid vectors and by eradicating hosts like wild mustard. Alum dusted on stumps has been found effective in controlling storage rots caused by *Erwinia*.

Important pests include: diamond-back moth (*Plutella xylostella*) for which chemical control is increasingly ineffective because of the quick build-up of resistance to all categories of insecticides, whereas biological control with BT (*Bacillus thuringiensis* preparates), sex pheromones and parasitoids (*Diadegma semiclausum* in cool climates, *Apanteles plutellae* in hotter climates) is promising; leaf webber (*Crocidolomia binotalis*). Occasional pests are webworm (*Hellula undalis*), cutworm (*Spodoptera littoralis*), flea beetle (*Phyllotreta* spp.), cabbage butterfly (*Pieris canidia*) and cabbage aphid (*Brevicoryne brassicae*). Indian mustard (*Brassica juncea* (L.) Czernjaew) may be used as trap crop for diamond-back moth and other pests when planted in rows between cabbage; chemical control can then be restricted to the mustard plants.

Harvesting Well filled-out and solid heads are cut, usually with a few wrapper leaves attached, 2–3 months after transplanting. The period of harvesting is 1–2 weeks, F_1 hybrids maturing more uniformly than open-pollinated cultivars.

In Thailand the lateral shoots from decapitated stumps are sometimes harvested as a sort of loose-leaved Brussels sprouts.

Yield Open-pollinated cultivars yield 10–15 t/ha, F_1 hybrids 40–60 t/ha under optimum growing conditions. In tropical regions yields are generally highest above 800 m altitude.

Seed yields are 200–1000 kg/ha in temperate climates.

Handling after harvest Cabbage can be stored for 7–10 days in a cool (20°C), well-aerated and dark space. Transportation can be in ventilated boxes, net bags or lightweight Hessian sacks. At 1°C and high humidity (95–98%) cabbage can be kept for 2–3 months.

Genetic resources Working and germplasm collections of white cabbage and other Brassica crops are available in several research centres in Europe, Commonwealth of Independent States (Vavilov Institute, Petersburg), United States, India, Malaysia, Japan, etc. Preservation of germplasm from the centres of genetic diversity (Mediterranean region) appears adequate.

Breeding Present breeding programmes aim at F_1 hybrids based on single crosses between inbred lines. Inbreeding is effected by bud-pollination or treatment with CO_2 (2–10%) before bee pollination to temporarily break the self-incompatibility.

Main breeding objectives include: head shape and size, internal firmness, leaf configuration and colour, core (= internal stem) length, taste, vitamin C content, earliness, standing ability (delayed splitting of the head at maturity), productivity, heat tolerance, resistance to diseases, pests and tip burn (physiological disorder).

Prospects The importance of white cabbage will further increase in South-East Asia. Heat-tolerant cultivars enable cultivation at lower elevations, but market gardening will continue to prevail in the highlands because of higher yield potential, better head quality and fewer diseases and pest problems. Considerable progress is being made with effective methods of integrated pest management in cabbage (Malaysia, Indonesia, Taiwan) and this will reduce pesticide use. Cultivars resistant to cabbage yellows and black rot are increasingly becoming available. However, clubroot is spreading fast in areas with intensive market gardening and cultivars with durable resistance will not be available in the medium term. Methods of control by antagonists to the pathogen deserve more attention.

The development of DNA markers by plant biotechnology for more precise indirect screening for resistance to diseases and pests, as well as other characteristics, will considerably increase breeding efficiency in cabbage. Cytoplasmic male sterility might eventually replace self-incompatibility as a more reliable technique for hybrid seed production, but a number of physiological problems have to be overcome.

Literature |1| Bos, G. & Sjarifudin S., 1977. Varietal screening trials of white cabbage, cauliflower and chinese cabbage on Java. Bulletin Penelitian Hortikultura [Horticultural Research Bulletin] 5(6): 71–91. |2| Bull, P.B., 1982. Horticultural note No 3: Cabbage. Harvest (DPI Konedobu, Papua New Guinea) 8(3): 122–125. |3| Dickson, M.H. & Wallace, D.H., 1986. Cabbage breeding. In: Bassett, M.J. (Editor): Breeding vegetable crops. Avi Publishing Company, Westport, Connecticut, United States. pp. 395–432. |4| Grubben, G.J.H., 1977. Tropical vegetables and their genetic resources. Tindall, H.D. & Williams, J.T. (Editors). International Board for Plant Genetic Resources (IBPGR), Rome, Italy. pp. 81–90. |5| Nieuwhof, M., 1969. Cole crops. Leonard Hill, London, United Kingdom. 353 pp. |6| Talekar, N.S. (Editor), 1992. Proceedings of the second international workshop on the management of diamondback moth and other crucifer pests (10–14 December, 1990). Asian Vegetable Research and Development Center (AVRDC), Tainan, Taiwan. AVRDC Publication 92-368. 603 pp. |7| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 120–123. |8| Tsunoda, S., Hinata, K. & Gomez-Campo, C. (Editors), 1980. Brassica crops and wild allies: biology and breeding. Japan Scientific Societies Press, Tokyo, Japan. 354 pp. |9| Villareal, R.L., 1987. Genetic improvement of tropical and sub-tropical vegetable crops. Philippine Journal of Crop Science 12(3): 131–138.

H.A.M. van der Vossen

Brassica rapa L.

Sp. pl.: 666 (1753).
CRUCIFERAE
$2n = 20$

Major taxa and synonyms
- Cv. group Caisin – see separate article.
- Cv. group Chinese Cabbage – see separate article.
- Cv. group Mizuna: Toxopeus, Yamagishi & Oost in Cruc. Newsl. 12: 5 (1987). Synonyms: *B. japonica* Makino (1912) non (Thunb.) Sieb. (1865/66), *B. campestris* L. ssp. *nipposinica* (Bailey) Olssen (1954), *B. rapa* L. ssp. *nipposinica* (Bailey) Hanelt (1986).
- Cv. group Neep Greens: Toxopeus, Oost, Yamagishi & Prescott-Allen in Cruc. Newsl. 13: 9 (1988). Synonym: *B. perviridis* (Bailey) Bailey (1940) for certain forms (komatsuna).
- Cv. group Pak Choi – see separate article.
- Cv. group Taatsai: Toxopeus, Yamagishi & Oost in Cruc. Newsl. 12: 5 (1987). Synonyms: *B. narinosa* Bailey (1922), *B. campestris* L. ssp. *narinosa* (Bailey) Olssen (1954), *B. rapa* L. ssp. *narinosa* (Bailey) Hanelt (1986).
- Cv. group Vegetable Turnip: Toxopeus, Oost & Reuling in Cruc. Newsl. 9: 58 (1984). Synonyms: *B. campestris* L. ssp. *rapa* (L.) Hook.f. & Anders. (1875), *B. campestris* L. ssp. *rapifera* (Metzger) Sinsk. (1928), *B. rapa* L. ssp. *rapa* sensu auct. mult.

Vernacular names General: neep crops (En).
- Cv. group Mizuna: mizuna, mibuna, kyona (Jap/En).
- Cv. group Neep Greens: komatsuna, kabuna, turnip greens (Jap/En).
- Cv. group Taatsai: taatsai (Chin/En).
- Cv. group Vegetable Turnip: vegetable turnip (En). Rave, navet (Fr).

Origin and geographic distribution The origin of *B. rapa* is not known. The wide variation of neep crops evolved in different parts of the Eurasian continent. Besides Chinese cabbage, pak choi and caisin the leafy vegetable types (leaf neeps) comprise cv. groups Mizuna, Neep Greens and Taatsai, developed in temperate regions of

Asia. The many forms of vegetable turnip are highly regarded in Japan as well as in Europe where also fodder turnip used to be a very popular crop (root neeps). Oilseed types (seed neeps), grown for rape oil, are important in India and Canada.

The turnip is the oldest *B. rapa* crop on record. It was described in ancient Greek times of Alexander the Great, whose empire included the Middle East and Persia, from where it must have found its way to East Asia. Quite independently of each other in Europe and in Japan a well-defined, polymorphic group of vegetable turnips had been created by the 18th Century.

Uses All products, the foliage of the leaf neeps as well as the root of vegetable turnip, are fresh vegetables, consumed boiled or fresh in salads or fried in special dishes.

Production and international trade The cv. groups Mizuna, Neep Greens and Taatsai are most important in mainland China and in Japan. Cv. group Vegetable Turnip is most important in Japan. In South-East Asia they are occasionally cultivated in highland areas for a foreign clientele.

Properties Per 100 g edible portion the approximate composition of leaves is: water 90 g, protein 3 g, fat 0.4 g, carbohydrates 5 g, fibre 0–4 g, ß-carotene 4.6 mg, vitamin C 139 mg. The energy value is 118 kJ/100 g.

The roots contain per 100 g edible portion: water 90 g, protein 1 g, trace of fat, carbohydrates 8 g, fibre 0.7 g, trace of ß-carotene, vitamin C 25 mg. The energy value is 143 kJ/100 g.

Description Annual or biennial herb with stout taproot, often fusiform to tuberous (turnips). Stem erect, branched, up to 1.5 m tall. Leaves very variable, depending on cultivar, growing in a rosette during the vegetative stage; basal leaves more or less petioled, bright green, lyrate-pinnatipartite, dentate, crenate or sinuate with large terminal lobe and up to 5 pairs of rather small lateral lobes; lower cauline leaves sessile, clasping, pinnatifid; upper cauline leaves sessile, clasping, undivided, glaucous, entire to dentate. Inflorescence a loosely corymbiform raceme with open flowers overtopping the buds; pedicel 1–3 cm long; sepals yellow-green; petals yellow, clawed, 6–11 mm long; stamens 6, tetradynamous. Fruit a silique, linear, 4–10 cm × 0.2–0.4 cm, beak 0.5–3 cm long, seeds 20–30. Seed globose, 1–1.5 mm in diameter, dark brown with a fine distinct reticulum.

- Cv. group Mizuna consists of spontaneously tillering plants with pinnate leaves (mizuna cultivars) or entire leaves (mibuna cultivars).

Brassica rapa L. cv. group Vegetable Turnip – habit.

- Cv. group Neep Greens comprises essentially non-heading plants, including crops such as komatsuna, zairainatane, kabuna, turnip greens.
- Cv. group Taatsai typically grows a flat rosette of many small dark green leaves.
- Cv. group Vegetable Turnip consists of forms of which the storage organ (swollen hypocotyl and root), i.e. the turnip, is used as vegetable; the leaves may be used as a vegetable as well. Turnips vary widely in shape, from flat through globose to ellipsoid and cylindrical, blunt or sharply pointed, flesh white, pink or yellow, apex white, green, red, pink or bronze. All these characteristics may occur in cultivars in any imaginable combination.

Growth and development In general these are fast-growing crops, harvestable 6–15 weeks after sowing, depending on type and season. Biennial types bolt after a period of relatively low temperatures. In the tropics these crops are only suitable for cultivation at higher altitudes (above 800 m).

Other botanical information In the literature, the taxonomy of *B. rapa* is confused. Often the name *B. campestris* L. is used for this species, but *B. rapa* was recently proven to be the correct name. In most floras *B. rapa* is roughly divided into 2 subspecies: ssp. *rapa* for the plants with swollen roots, cultivated for vegetable and for fodder; and ssp. *campestris* (L.) Clapham (syn.: ssp. *oleifera* DC.) for the plants mainly cultivated for the oil of its seeds. Many infraspecific classifications have been proposed, each trying to capture the wide variation of the cultivated forms in a taxonomic system, the result always being unsatisfactory. A classification system according to the code for the nomenclature of cultivated plants is followed here. It arranges cultivars into cultivar groups; it seems more promising but is still being tested.

Ecology The four cv. groups described require the lower temperatures of tropical highlands and are well adapted to long-day conditions. They have a high water requirement. Most cultivars of vegetable turnip require a degree of cold induction for flowering which will not be met in tropical highlands below 2000 m.

Agronomy Plants should be grown on well-watered, raised beds of light, well-manured soil either by direct sowing or with transplants raised in a densely sown seed-bed. They are very responsive to N fertilizers. In the first few weeks of growth, clean weeding should be practised. The limited cultivation experience with these crops in tropical highlands makes it difficult to discuss diseases and pests. The use of healthy seed is of major importance. At all costs clubroot disease (*Plasmodiophora brassicae*) should be kept out of any *Brassica* crop. The disease is often introduced in the soil on roots of transplants from other infested areas. It can spread rapidly with irrigation water and once the disease is established it can only be controlled by growing non-host (non-Brassica) crops for 5 or more years.
Yields will vary widely according to the type and life cycle of the crop concerned, 30–50 t/ha of fresh product being the range for well-managed crops. The produce should reach markets on the second day after harvesting at the latest. A good infrastructure is essential.

Genetic resources and breeding Major germplasm collections are present in gene banks in Japan, the United Kingdom and the United States. No breeding work is going on in any of the cv. groups described beyond maintaining existing cultivars marketed by the major international Japanese and European seed firms. *B. rapa* consists of a range of diverse crops all of which are completely cross-compatible and characters may be recombined at will using conventional seed breeding principles.

Prospects In South-East Asia, the neep crops described will be of interest to non-traditional middle and higher income groups in the larger cities who may be prepared to pay extra for the new crop products. The crops will add to the existing variety. Several crops have been introduced on a trial basis in recent years by European/Japanese/Korean seed firms. *B. rapa* as a whole offers wide prospects for the development of new vegetables adapted to specific ecological conditions and market preferences.

Literature |**1**| Jonsell, B., 1982. Brassica. In: Polhill, R.M. (Editor): Flora of tropical East Africa. Cruciferae. A.A. Balkema, Rotterdam, the Netherlands. pp. 3–7. |**2**| Mansfeld, R., 1986. Verzeichnis landwirtschaftlicher und gärtnerischer Kulturpflanzen (ohne Zierpflanzen) [Register of agricultural and horticultural plants in cultivation (without ornamentals)]. Schultze-Motel, J. et al., editors 2nd edition. Springer Verlag, Berlin, Germany. Vol. 1. pp. 300–306. |**3**| Oost, E.H., Brandenburg, W.A., Reuling, G.T.M. & Jarvis, C.E., 1987. Lectotypification of Brassica rapa L., B. campestris L. and neotypification of B. chinensis L. (Cruciferae). Taxon 36(3): 625–634. |**4**| Shinohara, S. (Editor), 1984. Vegetable seed production technology of Japan. Shinohara's Authorized Agricultural Consulting Engineer Office, Tokyo, Japan. Vol. 1. pp. 115–123, 239–268. |**5**| Toxopeus, H., Oost, E.H., Yamagishi, H. & Prescott-Allen, R., 1988. Cultivar group classification of Brassica rapa L.: update 1988. Cruciferae Newsletter No 13: 9–11.

H. Toxopeus

Brassica rapa L. cv. group Caisin

Cv. group name is proposed here.
CRUCIFERAE
$2n = 20$

Synonyms *Brassica parachinensis* Bailey (1922), *B. chinensis* L. var. *parachinensis* (Bailey) Tsen & Lee (1942).

Vernacular names Caisin, flowering white cabbage (En). Mock pak choi (Am). Indonesia:

caisin, sawi hijau, sawi kembang. Malaysia: sawi bunga. Thailand: phakkwangtung, phakkatkheokwangtung.

Origin and geographic distribution Caisin is generally believed to have differentiated along with the leaf neeps (Chinese cabbage, pak choi) from the oil-yielding turnip rape, which was introduced into China from the Mediterranean area through western Asia or Mongolia. Caisin originated in middle China where it was selected and popularized for the use of its inflorescences. It may be seen as parallel variation in *B. rapa* comparable with Chinese kale (*B. oleracea* L. cv. group Chinese Kale) in *B. oleracea*. Where headed Chinese cabbage is hardly grown, caisin and the non-headed leaf neeps (e.g. pak choi) are indispensable vegetables. Caisin is cultivated in southern and central China, in South-East Asian countries such as Indonesia, Malaysia, Thailand, Vietnam, in other parts of Indo-China, and in some parts of West India.

Uses Caisin has been developed for use in the early flowering stage, although harvest before flowering is preferred in certain regions. The inflorescences are more tender and smoother (glabrous) than those of other leafy Brassica crops and plants are cut for fresh consumption when the flowers begin to open. It is delicious when stir-fried, retaining much of its crispness and its salts and vitamins in the process. Because of its general tenderness, it is not suited to pickling and other post-harvest processing.

Production and international trade Very limited data are available on production and externally traded volume of caisin. In each country, most caisin is consumed locally because it is very perishable. The production figures for caisin are usually lumped together with other leafy *Brassica* crops. In Indonesia it is one of the three most popular vegetables, together with kangkong and amaranth. In Thailand where caisin may be considered as the main leafy *Brassica* vegetable, reported area and production in 1988/'89 were 2783 ha and 46 437 t respectively.

Properties Per 100 g fresh edible portion, caisin contains: water 95 g, protein 1.2 g, fat 0.2 g, carbohydrates 1.2 g, vitamin A 5800 IU, vitamin B_1 0.04 mg, vitamin B_2 0.07 mg, niacin 0.5 mg, vitamin C 53 mg, Ca 102 mg, Fe 2.0 mg, Mg 27 mg, P 37 mg, K 180 mg, and Na 100 mg. The energy value is 54 kJ/100 g. The 1000-seed weight is approximately 3 g.

Description Annual taprooted herb, 20–60 cm tall, with usually open to erect but sometimes prostrate growth habit. Stem usually less than 1 cm in diameter, small in comparison to other leafy cabbages, usually profusely branched. Rosette leaves few, usually with only 1–2 leaf layers and with a 2/5 phyllotaxy, long-petioled, spathulate or oblong, bright green; stem leaves not clasping, petiolate, glabrescent to glabrous, green to purple-red, finely toothed when young; lower stem-leaves ovate to nearly orbicular; central stem-leaves ovate to lanceolate to oblong with long and narrow, grooved petioles that are sometimes obscurely winged; upper stem-leaves gradually passing into narrow bracts. Inflorescence a terminal raceme, elongating when in fruit; flowers bisexual, perfect, ca. 9 mm in diameter, cream-coloured to very light yellow, 4-merous; petals pandurate; stamens 6, tetradynamous. Fruit a silique, slender, up to 5 cm long with slender brief beak, containing 10–20 seeds. Seed globose, about 1 mm in diameter, smooth with faint raphal line.

Brassica rapa L. cv. group Caisin – habit.

Growth and development Caisin seed has no dormancy, but it is advisable to wait for at least a week after seed drying before sowing them. Caisin seeds require 3–5 days to germinate under optimum soil moisture and temperature (20–25°C).

The time to harvesting differs according to the cultivar; it varies from 40–80 days after sowing. Bolting and flowering generally are not depending on low temperatures; caisin tends to bolt early under long days. Bolting is generally indicated by the elongation of the main stem when the flower buds initiate and develop. After fertilization by insect pollinators like honeybees, the thin slender siliques develop rapidly and reach full length some three weeks later and are ready for harvest in another two-week period.

Other botanical information The cv. group Caisin can be considered a leaf neep or more specifically an inflorescence neep. Characteristic features of cv. group Caisin are its orbicular basal leaves, its hardly winged petioles and its non-clasping stem-leaves. It is rather similar to a European crop known as 'broccoletto' or 'cima di rapa' in Italy. The Asian and European crops are organoleptically distinguishable (the latter usually have a stronger flavour), but morphologically they are quite similar.

Ecology Caisin can be grown all-year round for its leaves and tender flower stalks in the subtropical and tropical zones, indicating that flower induction is not influenced by temperature. Generally, there is a tendency towards faster bolting during the long days of the summer at higher latitudes. A light, well-drained fertile sandy loam or clay-loam soil is best for caisin production. A soil pH of 5.5–6.5 is preferred.

Propagation and planting Caisin can be direct-seeded or transplanted. In subtropical areas, direct seeding is preferred. Normally this is done by broadcasting or by drilling the seeds. In the humid tropics, transplanting is preferable because of the relatively poorer conditions for growth and development. Moreover, direct seeding is normally expensive and time-consuming as close attention to thinning and weeding is necessary.

Seedlings for transplanting are often raised in special nurseries, such as well-prepared raised beds or specially prepared seed boxes. Seeds are broadcast or sown in shallow furrows, covered lightly with soil, and then adequately watered. Seeds may be previously dusted with fungicides (e.g. thiram) to fend off attack by harmful diseases such as damping-off. In the tropics, the nursery is often covered with straw. Watering two to three times daily is necessary to encourage vigorous growth of the young plants. Watering the seedlings once a week with a 0.1% urea or ammonium sulphate solution is sometimes practised to further enhance plant vigour. Seedlings are hardened by lightly withholding water about one week before transplanting. Two to three weeks after sowing the seedlings are ready for transplanting.

Field beds should be well-prepared, raised, about 1 metre wide with between-bed furrow space of 20–25 cm. With direct seeding, spacing is about 10–15 cm × 10–15 cm between hills and rows. In transplanting, the young seedlings are set in such a manner that the first true leaves are approximately at ground level when the hole is filled with soil. Between-plant spacing varies depending upon cultivar types. Early cultivars are normally spaced about 30 cm; late-maturing cultivars require wider spacing. Spacing between the rows could be 30–40 cm. Seedlings should be watered quickly after they have been transplanted in the field.

Husbandry Caisin grows moderately fast and therefore requires adequate moisture for optimum growth and development. In the tropics, watering with 5–7 mm per day or 2–3 cm every four days appears to be sufficient to sustain growth. The weeds must be hoed until the plants are able to outgrow them. Like the other leafy cabbages, caisin responds well to compost and fertilizer application. Often, 10–15 t/ha of compost combined with 60–110 kg/ha of N, 40–60 kg/ha of P_2O_5 and 80–100 kg/ha of K_2O are adequate to sustain a good crop. Nitrogen is often split-applied, half of the total as basal fertilizer and the residual side-dressed two weeks or so later. With late-maturing cultivars, more nitrogen is often applied, split into at least three applications. The last is normally applied a week before the onset of flower stalk formation. Caisin is easy to grow and as many as 10 crops can be grown successively without rotation except changing the cultivar type.

Diseases and pests Soft rot (*Erwinia carotovora*), downy mildew (*Peronospora parasitica*), turnip mosaic virus (TuMV), clubroot (*Plasmodiophora brassicae*), *Alternaria* leaf-spot (*A. brassicae* or *A. brassicicola*) and *Sclerotinia* rot are the major diseases affecting cruciferous vegetables including caisin. Soft rot is very serious during the hot wet season. No effective control measures have been developed; however, early maturity or rapid growth usually enable crops to escape this disease. Fungicides such as dithane, maneb, and zineb can effectively control downy mildew and the *Alternaria* leaf-spots. Turnip mosaic virus (TuMV) is serious during the dry season. It can be reduced by controlling aphids which serve as the vector. Liming is known to reduce the incidence of clubroot. Field sanitation should be rigorously observed to reduce the spread of this disease to clean fields.

Diamond-back moth (*Plutella xylostella*) is the most destructive insect and is most common during cool dry periods. It usually is controlled by chemical sprays but the insect quickly develops pesticide resistance. Integrated pest management (IPM) using biological parasites such as *Diadegma eucerophaga* and *Apanteles plutellae*, combined with selective microbial insecticides like *Bacillus thuringiensis* provide a satisfactory control, besides being safe and sustainable. Other pests such as the webworm (*Hellula undalis*) and leaf webber (*Crocidolomia binotalis*), aphids (especially during the dry period) and striped flea beetle (*Phyllotreta striolata*) can sometimes be major limiting production factors.

Harvesting Caisin is ready for harvest about 40 days after sowing in the earliest maturing cultivar. This is normally a once-over harvest by pulling the whole plant. In contrast, the more vigorous, late-maturing cultivars could be in the field for as long as 80 days and one or two well-grown side shoots could be harvested later after harvesting the main stalk.

Yield The estimated yield range of caisin in the subtropics such as Taiwan is 10–20 t/ha. In 1989, the average productivity in Taiwan was 15 t/ha. The average yield reported in Thailand in 1988/'89 was 17 t/ha.

Handling after harvest The harvested plants should be moved immediately to a shady place. Keeping the plants covered with wet materials or sprinkling occasionally with water could reduce water loss and apparent wilting. They are then washed well and cleaned of old, decaying, injured or unsightly leaves to prepare them for the market. The harvested plants or leaves could be packed in suitable containers such as bamboo baskets (as normally practised in the Asian tropics) but other materials such as plastic boxes or paper cartons with holes to allow air circulation may be used, if locally available and inexpensive. Packages for supermarkets are often of 300 g capacity; caisin normally lasts two days in these containers. For the traditional markets, caisin is usually prepared in 300 g bunches and normally lasts only one day.

Genetic resources China is considered as the centre of diversity of caisin. The best known form of differentiation is in crop duration. Reported maturity of available cultivars ranges from 40 to 80 days. Usually caisin has green foliage, but a purple-leafed cultivar is available in Taiwan. Caisin collections are available in China, Japan, and Taiwan although collections in the latter two countries are relatively modest.

Breeding There is no major breeding effort to improve caisin. Farmers in South-East Asia use local cultivars from own seed or from local seed dealers. Some cultivars are imported, usually from China or Taiwan. The variability between cultivars available in the region appears to be small. Some superior selections from local cultivars are available from seed companies in Indonesia, Thailand and the Philippines. Any attempt to improve caisin through breeding begins with simple breeding techniques, such as mass selection, applied to genetically variable cultivars. No data on disease resistance of commonly grown cultivars are available, to derive any hypotheses on the potential of breeding for disease resistance.

Prospects The potential to genetically improve caisin using the variation in presently available cultivars seems to be limited. However, enforced introgression from the leaf neeps is easy and therefore the available genetic diversity of the latter could be readily exploited in any serious breeding effort on this vegetable. The prospect of successful technology for integrated pest management to control insect pests in the hot and humid lowland areas appears to be good.

Literature |**1**| Bantoc Jr, G.B., 1970. Chinese cabbage and the mustards. In: Knott, J.E. & Deanon Jr, J.R. (Editors): Vegetable production in South-East Asia. University of the Philippines Press, Los Baños, the Philippines. pp. 276–284. |**2**| Bettencourt, E. & Konopka, J., 1990. Directory of germplasm collections. 4. Vegetables. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. pp. 55–95. |**3**| Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 208–211. |**4**| Li, Chia-wen, 1984. Chinese cabbages of China. Agricultural Publishing Company, Beijing, China. 234 pp. |**5**| Opeña, R.T., Kuo, C.G. & Yoon, J.Y., 1988. Breeding and seed production of Chinese cabbage in the tropics and subtropics. Technical Bulletin No 17. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. 92 pp. |**6**| Teo, K.H. Christopher, 1970. Identification of some common Brassica species by their vegetative characters. The Malayan Agriculturist 9: 53–70. |**7**| Yamaguchi, M., 1983. World vegetables: principles, production and nutritive values. Avi Publishing Company, Westport, Connecticut, United States. pp. 218–231.

R.T. Opeña & D.C.S. Tay

Brassica rapa L. cv. group Chinese Cabbage

Toxopeus, Yamagishi & Oost in Cruc. Newsl. 12: 5 (1987).

CRUCIFERAE

$2n = 20$

Synonyms *Brassica pekinensis* (Lour.) Rupr. (1860), *B. campestris* L. ssp. *pekinensis* (Lour.) Olsson (1954), *B. rapa* L. ssp. *pekinensis* (Lour.) Hanelt (1986).

Vernacular names (some in common with cv. group Pak Choi). Chinese cabbage, celery cabbage, Peking cabbage, petsai (En). Chou de Chine, chou de Shangton (Fr). Indonesia: petsai, sawi putih. Malaysia: petsai, sawi putih, kobis cina. Papua New Guinea: kapis. Philippines: pechay Baguio, wong bok. Cambodia: pe-chhaay, spéi khiew. Laos: kaad chiin. Thailand: phakkat-khaopli, phakkat-khaoyai. Vietnam: c[ar]i b[aws]c kinh.

Origin and geographic distribution Chinese cabbage is a native of China. It probably evolved from the natural crossing of Pak choi (non-headed Chinese cabbage), which was cultivated in southern China for more than 1600 years, and turnip, which was mainly grown in northern China. Much of its varietal differentiation took place in China during the past 600 years. Its derivatives were introduced into Korea in the 13th Century, the countries of South-East Asia in the 15th Century, and Japan in the 19th Century. An illustration of the headed shape of Chinese cabbage with wrapping leaves was first recorded in China in 1753. At present, Chinese cabbage is grown all over the world.

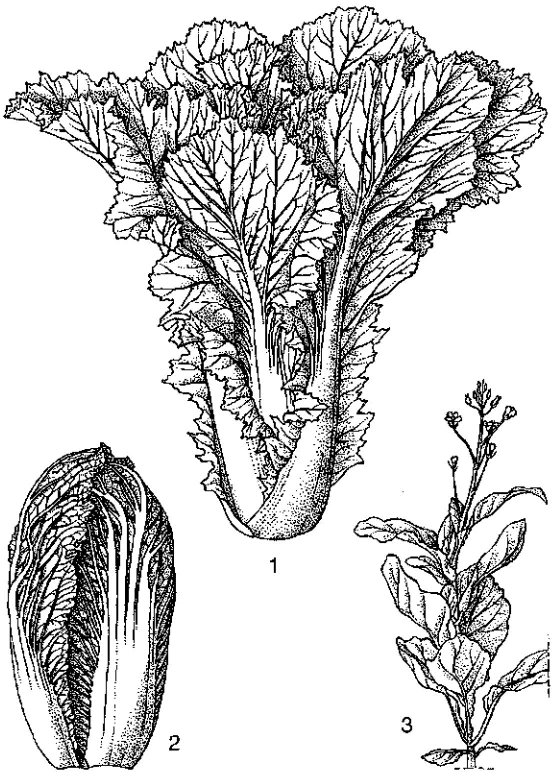
Uses Chinese cabbage is used from crisp-raw, to tender-crunchy, to silky-soft over-cooked. Fresh leaves are stir-fried, added to delicate broths during the last few minutes of cooking, or simmered for a long period of time in thick, stewy soup. In East Asia, it is a standard part of meals in the form of simple salted and spiced pickles, whether sweet-sour and fresh, or hot-peppery and long-fermented. Leaves treated this way can be kept for several weeks. Raw, succulent white midribs of the leaves are also sliced or coarsely shredded for salads, or cut in strips for platters. Leaves are also dried and kept for weeks before being used as vegetables.

Production and international trade Chinese cabbage is one of the most important vegetables in East Asia. It is favoured by small farmers because of its short cropping duration and wide adaptation to different growing conditions. The cultivated area in China was about 260000 ha in 1982, or 27% of the total vegetable production area. In Japan, about 32000 ha were planted with this crop in 1988, or 5% of the total vegetable production area. In Korea, the production area was about 48000 ha in 1986, or 13% of the total vegetable production area. In Taiwan, the production area of 8000 ha in 1988, or 4% of the total vegetable production area, was second only to white cabbage. In Thailand, some 8000 ha were planted with this crop and Pak choi in 1986. In South-East Asia, there has been a considerable increase in production in recent years because of the availability of cultivars adapted to tropical conditions. International trade of this crop in the region is negligible. The bulk of the seeds are imported from temperate or subtropical countries, mostly Japan and Taiwan.

Properties Per 100 g edible portion, leaves contain approximately: water 95 g, protein 1.2 g, fat 0.2 g, carbohydrates 2.2 g, fibre 0.5 g, Ca 49 mg, Fe 0.7 mg, vitamin A 0.9 mg, and vitamin C 38 mg. It is low in energy value, about 65 kJ/100 g. The 1000-seed weight is about 3 g. Seeds contain 35–40% oil, and keep their viability well in air of low relative humidity.

Description Biennial herb, cultivated as an annual, 20–50 cm tall during the vegetative stage, reaching up to 1.5 m in the generative stage. Taproot and lateral roots prominent in older plants, forming an extensive, fibrous, finely branched root system. During the vegetative stage leaves are arranged in an enlarged rosette, forming a short conical more or less compact head, with ill-defined nodes and internodes and alternate heading and non-heading leaves; leaves 20–90 cm × 15–35 cm, shape varying with growth stage; outer heading leaves narrowly ovate with long, winged petioles, dark green; inner heading leaves broad, subcircular, whitish-green; flowering stem leaves lanceolate, much smaller than heading leaves, with broad compressed petioles and blades, clasping the stem. Inflorescence an indeterminate, terminal, much-branched raceme, 20–60 cm long; pedicel 1–1.5 cm long; flowers bisexual, perfect; sepals 4, 0.5 cm long, yellow-green; petals 4, 1 cm × 0.5 cm, bright yellow; stamens 6, tetradynamous. Fruit a silique, 7 cm × 3–5 mm, glabrous, with short and stout beak, 10–25-seeded. Seed globose to ovoid, 1–2 mm in diameter, greyish-black to red-brown.

Growth and development Chinese cabbage seeds take 3–5 days to emerge at 20–25°C. There are normally five leaves in two whorls or eight



Brassica rapa L. cv. group Chinese Cabbage – 1, habit; 2, head; 3, flowering shoot.

leaves in three whorls. These first whorls of leaves are fully expanded into more or less horizontal position. Seedlings are usually set out to the field at this stage. Subsequent leaves are continually formed, and the inner leaves start to grow more upright. Heading begins at about the 12th to 13th leaf stage for the early-maturing cultivars or the 24th to 25th leaf stage for the late-maturing, when the innermost leaves start to curve inwards and touch at their tips. As new leaves form and expand around the crown, their margins become temporarily trapped against the upright leaves. In the early stages of head formation, these temporarily trapped leaves finally unfold, become upright, and roll outward to develop into the outer head leaves. As more leaves are produced, they become increasingly entrapped and remain folded to form the head. There is a limited increase in height at this stage, but the plant assumes its characteristic headed shape. Some 50–100 days after sowing, the heads can be harvested as vegetable. The stem normally elongates (bolts) as the flower buds initiate and develop. Flowers are insect-pollinated, and have an outcrossing type of mating. After fertilization, the siliques develop rapidly and reach their full size within 3–4 weeks. The fully developed siliques require another 2 weeks to mature.

Other botanical information Cv. group Chinese Cabbage comprises headed and semi-headed cultivars of leaf neeps with characteristically winged petioles. In the taxonomic literature it has often been classified as belonging to *B. chinensis* L., together with cv. group Pak Choi. Cv. group Pak Choi comprises non-headed leaf neep cultivars, with fleshy, conspicuous, but not winged petioles.

According to shape, size and organization of the head, three basic types of Chinese cabbage can be distinguished from which numerous cultivars have developed:
- *cephalata* type: head large, compact, ovoid to obovoid; the heading leaves curve inward and overlap at the top;
- *cylindrica* type: head compact, erect and elongated, more or less pointed and spirally wrapped at the top; with or without heading leaves over the top;
- *laxa* type: head loose, open; the top and the upper margins of the heading leaves may be erect or curled outward, and are yellow or yellow-white.

Ecology Chinese cabbage grows best and forms heads in climates with temperatures in the range of 12–22°C; therefore they are usually grown at high altitudes (500–1500 m) in the tropics. Temperatures above 25°C prevent most temperate cultivars from forming marketable heads. High temperatures also enhance tip burn (physiological disorder) and the development of diseases. The heat-tolerant cultivars developed by seed companies nowadays make it possible to produce good Chinese cabbage crops in the lowlands. Daylength does not affect head formation but short days with reduced amounts of incoming radiation will reduce the growth rate and weight of leaves. The water requirement greatly increases with advancing growth stages, particularly during the heading stage. Drought stress in the heading stage prevents head formation. Flooding during the rainy season makes normal plant growth impossible, especially the formation of heads. Crops usually die within 3–5 days of flooding in the lowland tropics because of the synergistic effect of high temperatures.

A period of 1–4 weeks at 5–13°C, either before or after heading, is required for flower initiation to take place. The sensitivity to low temperature increases with increasing plant age. A combination of low temperature and long day is required for maximum flowering. Devernalization may occur at temperatures above 16°C. Heat-tolerant genotypes tend to bolt early if grown in the cool tropical highlands. Chinese cabbage thrives well in a fertile, clayey loam soil with a pH of 6.0–7.5 and a large amount of organic matter.

Propagation and planting Chinese cabbage is propagated by seed. The seeds of either open-pollinated cultivars or hybrids are supplied by seed firms or national programmes. To minimize seed-borne diseases, the seeds are sometimes soaked in 50°C water for 25 minutes and then in 1% sodium hypochlorite for 10 minutes, if the seeds are not treated in advance by the seed supplier. Both direct seeding and transplanting methods are employed. For direct seeding, seeds are dibbled in drills and then covered with a thin layer of soil and rice straw. At the 2–3 true leaves stage, stands are thinned by cutting to keep vigorous normal seedlings at 1 plant/hole and 30–50 cm between plants. Transplanting with the use of a nursery to raise seedlings is preferred to direct seeding to shorten the crop duration in the field and to secure a better and more uniform stand. In this case, seeds are sown in pots at 2–3 seeds per pot, or per hole in seedling beds at a spacing of 6 cm × 6 cm, and then covered with a thin layer of soil, compost or rice hulls. Seedlings at the 2–3 true leaves stage are thinned to one seedling per pot or hole. The growth medium for seedling preparation is sometimes disinfected by steam sterilization. About 3–4 weeks after sowing, seedlings with 5–8 leaves are transplanted to the field, usually in the late afternoon, at 50 cm between rows and 30–50 cm within rows on a 1.5 m wide raised bed. The quantity of seeds required for a stand of 30 000 plants/ha for both methods is 0.5–0.8 kg (175 000–275 000 seeds). Land preparation is usually carried out by plowing with a water buffalo, roto-tilling and then harrowing, or hoeing.

Husbandry As most of the feeder roots of this vegetable grow to a depth of 30 cm, irrigation to maintain the top 30 cm at a soil moisture level between 65–85% of field capacity is of great importance. For both transplanting and direct seeding methods, water is provided right after sowing by fine spraying, or by using a small watering can after transplanting. When the seedlings have established in the field, furrow irrigation is practised once every 7–10 days, depending on ambient conditions. As a rule, the plants are irrigated if wilting occurs in midday or early afternoon. In the rainy season, good soil drainage is essential for plant survival. Mulching with rice straw is useful in reducing weeds, soil erosion, soft rot, and downy mildew. Raised beds at 30 cm or earthing-up in combination with weeding can minimize flooding damage during the rainy season. Leaf-tying at the early stage provides a good initial posture for heading.

Both fast-acting chemical fertilizers and slow-acting organic fertilizers are normally used. In the case of direct seeding, part of the chemical fertilizer is given at sowing and the rest at intervals of 14–20 days after thinning. In the case of transplanting, part of the chemical fertilizer is incorporated into the bed, the rest being split-applied after transplanting, at intervals of 10–14 days. The recommended rates are 120–200 kg/ha of N, 40–60 kg/ha of P_2O_5 and 70–150 kg/ha of K_2O. Depending on the cropping conditions, more chemical fertilizer may be added during the rest of the growing cycle. Organic fertilizers such as compost, green manure, chicken or pig manures, oil cakes, or night soil are essential to improve the efficiency of chemical fertilizers and to retain optimum physical and chemical soil conditions. Chinese cabbage is grown in rotation with field crops or in multiple cropping systems with other vegetables, preferably with unrelated crops to prevent a build-up of insects and diseases.

Diseases and pests Chinese cabbage often suffers from various diseases and pests. Soft rot (*Erwinia carotovora*) is the most damaging disease in the humid tropics. The incidence of soft rot can be dramatically reduced by shortening the growth period. Downy mildew (*Peronospora parasitica*) and turnip mosaic virus (TuMV) are important in dry environments. Some new cultivars possess a considerable level of resistance to both pathogens. Clubroot (*Plasmodiophora brassicae*) and *Alternaria* leaf-spot are also serious, although confined to certain tropical highland areas. Tip burn, a Ca-related disorder of the marginal tissue of either outer wrapper leaves or inside the head, also often occurs in tropical lowlands. Split applications of nitrogen fertilizer and a decreased total rate of fertilizer are recommended as means of avoiding too vigorous an initial growth, a predisposition for tip burn.

Diamond-back moth (*Plutella xylostella*) is a most destructive pest, particularly during the dry season. The combination of two larval parasites (*Diadegma eucerophaga* and *Apanteles plutellae*) and a bacterial insecticide, *Bacillus thuringiensis*, can provide satisfactory biological control of diamondback moth. Brief sprinkler irrigation repeated daily at dusk is also effective to decrease mating, oviposition and, consequently, infestation. Aphids are also serious during the dry season. Damage by adult striped flea beetles (*Phyllotreta striolata*) is common on leaves in the dry season. Cabbage webworm (*Hellula undalis*) is serious during the wet season.

Harvesting Heads are harvested when compact, i.e. they do not collapse easily when pressed firmly with both hands. Prematurely harvested heads lack development of young, tender leaves and are relatively light; over-matured heads may burst, thus reducing marketability. The head is cut at the base, keeping the entire head intact. Outer leaves are trimmed to 2–3 non-heading leaves for protection during transport.

Yield Average crop yields range from 10–60 t/ha, depending upon season, cultivar, duration, and location. Average head weight ranges from 0.5–4.5 kg.

Handling after harvest Most tropical countries face difficulties of transportation and storage. Bamboo baskets, the most frequently used packing material in South-East Asia, are often overloaded. This causes injuries and leads to infections by pathogens. Under humid, tropical conditions, Chinese cabbage can be stored for only a few days. Lack of storage facilities, adequate packing materials and sufficient transport hampers the marketing of the crop.

Genetic resources China has the richest source of Chinese cabbage germplasm; by the end of 1985 about 1000 landraces were collected and about 150 of them have been placed in long-term storage in the Chinese Academy of Agricultural Sciences (CAAS), Beijing. Over the years, AVRDC has also built up a sizeable collection of about 860 accessions. AVRDC's collection is also preserved at the Institute of Horticultural Research, Wellesbourne, United Kingdom.

Breeding Objectives of varietal improvement in South-East Asian national programmes, private seed firms, and AVRDC, are heat tolerance (defined as the ability to form heads in hot weather), non-bitter flavour, high yield, early maturity and resistance to major diseases. Improved open-pollinated cultivars, synthesized from intercrosses of the new breeds, and hybrids, showing pronounced hybrid vigour and uniformity, obtained upon crossing two homozygous inbred lines, have been released in the region. Desirable characteristics may be obtained from any other form of *B. rapa* by hybridization and applying standard breeding procedures.

Prospects The advent of the heat-tolerant, tropically adapted cultivars open up possibilities for production in the humid lowland tropics. However, an increase in the cultivation area in South-East Asia is only to be expected with the introduction of improved production technology as well as improved storage, transport and marketing facilities. The use of hybrid seed is of growing importance and its share in the international seed trade is increasing. Countries that depend entirely on this trade are looking for means to produce their own seed. The countries of South-East Asia could develop seed production of tropical cultivars in the relatively cool, dry highland climate. A skilled cadre of seed production specialists and appropriate technology for seed production are required.

Literature |1| Chen, C., 1984. Morphology of Chinese cabbage. Science Publishing Company, Beijing, China. 116 pp. |2| Jiang, M.C., 1981. Cultivation of Chinese cabbage. Agriculture Publishing Company, Beijing, China. 260 pp. |3| Li, Chiawen, 1984. Chinese cabbages of China. Agricultural Publishing Company, Beijing, China. 234 pp. |4| Opeña, R.T., Kuo, C.G. & Yoon, J.Y., 1988. Breeding and seed production of Chinese cabbage in the tropics and subtropics. Technical Bulletin No 17. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. 92 pp. |5| Talekar, N.S. & Griggs, T.D. (Editors), 1981. Chinese cabbage. Proceedings of the First International Symposium of Chinese Cabbage. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. 489 pp. |6| Toxopeus, H., Oost, E.H., Yamagishi, H. & Prescott-Allen, R., 1988. Cultivar group classification of Brassica rapa L.: update 1988. Cruciferae Newsletter No 13: 9–11.

C.G. Kuo & H. Toxopeus

Brassica rapa L. cv. group Pak Choi

Toxopeus, Oost & Reuling in Cruc. Newsl. 9: 58 (1984) ('Pak-Choi').

CRUCIFERAE

$2n = 20$

Synonyms *Brassica chinensis* L. (1759), *B. campestris* L. ssp. *chinensis* (L.) Makino (1912), *B. rapa* L. ssp. *chinensis* (L.) Hanelt (1986).

Vernacular names (some in common with cv. group Chinese Cabbage). Pak choi, Chinese cabbage, celery cabbage (En). Chou de Chine, chou de

Shangton (Fr). Indonesia: paksoi, pecai, sawi putih. Malaysia: pak choi, sawi putih. Papua New Guinea: kapis. Philippines: pechay. Cambodia: pechhaay, spéi khiew. Laos: kaad chiin. Thailand: phakkat-khaokwangtung, hong-tae, hong-how. Vietnam: c[ar]i thi[af], c[ar]i ng[oj]t, c[ar]i b[ej] tr[aws]ng.

Origin and geographic distribution Pak choi evolved in China and its cultivation was recorded as far back as the 5th Century AD. It is widely cultivated in southern and central China, and Taiwan. This group is a relatively new introduction in Japan where it is still referred to as 'Chinese vegetable'. It was introduced to South-East Asia in the Malacca Straits Settlement in the 15th Century. At present, it is widely cultivated in the Philippines and Malaysia, and to a limited extent in Indonesia and Thailand. In recent years it has gained popularity in northern America, Europe and Australia where there are concentrations of east Asiatic emigrants.

Uses Pak choi is mainly grown for its immature but fully expanded tender leaves, but all above-ground parts are edible. The succulent petioles are often the preferred part. It is used as the main ingredient for soup and stir-fried dishes. In Chinese cuisine, its green petioles and leaves are also used for decorating dishes. It is seldom eaten raw or pickled.

Production and international trade In the Philippines, pak choi is one of the major leafy vegetables. From 1983–1986, the average annual production was 25 500 t from 3800 ha. Malaysia produced in 1986 50 000 t of leafy *Brassica* crops from 1250 ha, half of which could be pak choi; 2000 t were exported to Singapore. In Indonesia and Thailand, pak choi is a minor vegetable as it is a relatively new introduction. In China pak choi is one of the most important leafy vegetables and it represents 30–40% of the total vegetable production.

Properties Trimming loss of harvested pak choi is about 14%. Per 100 g fresh edible portion pak choi contains: water 93 g, protein 1.7 g, fat 0.2 g, carbohydrates 3.1 g, fibre 0.7 g, ash 0.8 g. It is a good source of vitamins and minerals: ß-carotene 2.3 mg, vitamin C 53 mg, Ca 102 mg, P 46 mg and Fe 2.6 mg. The energy value is 86 kJ/100 g. The 1000-seed weight is 3–5 g.

Description Erect biennial herb, cultivated as an annual, in vegetative state 15–30 cm tall, in generative stage up to 70 cm tall, glabrous, dull green. Leaves arranged spirally, not forming a compact head but spreading, 15–30; petioles enlarged, terete or flattened, 1.5–4 cm wide and 0.5–1 cm thick, growing upright forming a subcylindrical bundle, white, greenish-white to green; leaf-blade orbicular to obovate, 7–20 cm × 7–20 cm, entire, tender, smooth or blistering, green to dark green, shiny; stem-leaves auriculate-clasping. Inflorescence a raceme with pale yellow flowers about 1 cm long; flowers bisexual, perfect; petals 12 mm × 6 mm. Fruit a silique, 2.5–6 cm × 3.5–6.5 mm, slender, with slender beak up to 2 cm long, containing (10–)20(–30) seeds. Seed subglobose, ca. 1 mm in diameter, reddish to blackish-brown. Germination is epigeal; cotyledons notched, kidney-shaped.

Brassica rapa L. cv. group Pak Choi – habit.

Growth and development At optimal temperatures (20–25°C), germination takes place in 3–5 days. The first two true leaves are opposite, later leaves are arranged spirally. A 40 to 45-day cultivar with about 30 leaves at harvest has about 10 juvenile leaves each weighing 1–4 g, 14 fully grown and expanded leaves weighing 10–26 g, and 6 small inner leaves weighing 4–16 g. Pak choi is typically cross-pollinated. Two pairs of nectaries in the flower attract insects. It takes about 35–45 days from anthesis to pod maturation.

Other botanical information Cv. group Pak Choi is defined as comprising cultivars that are non-headed, with conspicuous, fleshy, not winged petioles in contrast to cv. group Chinese Cabbage that comprises headed or semi-headed cultivars with winged petioles. In China, pak choi is the largest group of the non-headed leaf neeps. Cultivars are classified into autumn, winter, spring and summer types. Within each of these seasonal groupings, the cultivars are further subdivided according to their degree of erectness, petiole colour (white or green), plant height (short from 20–30 cm, medium, or tall from 45–60 cm), shape of the petiole (flat with thickness/width ratio of 0.4, intermediate with ratio of 0.4–0.7, or round with ratio of 0.7), leaf-blade colour (yellowish-green, green or dark green), and leaf-blade surface (smooth or blistered). The short plant type has a ratio of petiole length to leaf-blade length smaller than 1, the medium plant type about 1, and the tall plant type greater than 1. There are few summer cultivars, which reflects the lack of variation of the tropical type.

Compared with countries in East Asia, in South-East Asia pak choi is less well known than caisin (*B. rapa* cv. group Caisin), except for the Philippines. In Indonesia the local names of pak choi overlap with those of the caisin group as 'sawi baso', 'caisin', etc. In Thailand, the group is a recent introduction. It is called after the first introduced cultivars: 'Hong-Tae' (meaning emperor in the Chinese Chaozhou dialect) for the green petiole and dark green leaf type, and 'Hong-How' (meaning empress) for the white petiole and dark green leaf type. These two types have special roles in Chinese cuisine as the main vegetable dish and as garnish. They frequently feature in South-East Asian cookery books. They are clearly distinguished in the landrace purification and cultivar maintenance programmes of most South-East Asian seed companies. Another important type known as 'Hsiao Pai Tsai' which is common in Taiwan and China has light green, thinner and slightly wavy leaf-blades, and flat light green and partially winged petioles. This type is probably more related to the cv. group Chinese Cabbage.

Ecology Pak choi is a biennial but may behave as an annual depending on the cultivar and the environment. In South-East Asia, pak choi can be grown year-round in the lowlands. The seed crop is planted in the highlands to allow natural flower induction (vernalization). Towards the margins of the tropics, pak choi may seed during the relatively cool season. Vernalization at 5–12°C for 10–40 days is effective immediately following germination. Usually tropical cultivars require minimal cold treatment but some cultivars may need more than 40 days. Over-vernalization induces premature flowering, sometimes even at the seedling stage.

In the tropics the required light intensity for maximum growth of pak choi is not known. However, etiolation due to overcrowding and shading should be avoided. Pak choi withstands wet weather relatively well if not flooded. Fertile alluvial sandy to clayey loam with pH between 5.5–7.0 is preferred for cultivation. However, other soil types such as peat and latosols are also suitable if well provided with organic manure and fertilizers.

Propagation and planting Pak choi is propagated by seed. Seeds can be stored for at least a year at room temperature if dried to 5–7% moisture content and stored in moisture-resistant containers. Planting is by direct seeding or transplanting. Direct seeding at a rate of 1–5 kg of seed per ha is adopted mainly for the short (about 30-day) duration cultivars. It is carried out by broadcasting or by sowing in rows on ridges. Seeds are covered to a depth of about 1 cm by raking or spreading additional topsoil. Watering is done immediately after sowing. Mulching or a rain shelter is used to prevent washing off by heavy rain. The seed to be broadcast may be mixed with an equal amount of sawdust or sand with grain size the same as the seeds so that broadcasting can be done uniformly. Plant spacing should be 10–20 cm, which may be achieved by thinning and/or early harvesting of some plants.

In some countries transplants are preferred. Transplanting is done for the larger plant type and longer duration cultivars. For planting 1 ha, a 500 m^2 nursery bed is required at a seeding rate of 0.4–1.0 kg. The nursery bed is fertilized with 1 kg of farm compost, 10 g N, 10 g P, and 3 g K per m^2. Overcrowded patches should be thinned to prevent etiolation. Seedlings should be transplanted before or at the 5-leaf stage at a spacing of 15–20 cm, preferably in the evening, and watered immediately.

Husbandry The field should have fine tilth and be well-levelled. During land preparation, 10–20 t of manure, and 55–75 kg N, 40–80 kg P and 80–110 kg K per ha should be incorporated before beds of 1.0–1.2 m width and 30 cm height are formed. The distance between beds should be about 30–40 cm. Two weeks after transplanting another side dressing of 55–75 kg/ha of N should be applied. Alternatively, the same amount can be applied in split dosages as a 1–2% solution at 3–4-day intervals starting 1–2 weeks after transplanting. Good timing of the split N applications is important for continuous vigorous growth.

Weeding is done manually during thinning until the canopy closes. The soil is maintained sufficiently moist all the time at 65–85% field capacity. During hot dry spells the crop must be watered daily, preferably in the morning or evening. When furrow irrigation is used the bed width should be narrower (30–50 cm) to ensure irrigation water penetrates into the middle of the bed. Good drainage has to be provided in the root layer by using high beds. In the rainy season, a temporary rain shelter built from palm or fern fronds, or nylon netting should be used to prevent lodging and damage to the leaves.

Commercial growers usually cultivate pak choi as a sole crop. In many market and home gardens, intercropping is used with a long duration vegetable of another plant family in order to maximize land use. Planting in rotation with crops of other families is important, to prevent build-up of cruciferous diseases and pests.

Diseases and pests The heat- and wet-tolerant pak choi is relatively resistant to diseases. Due to its short growing period it often escapes soilborne diseases and pests. Seedling damping-off can be a problem if the soil and weather are too wet. It is controlled by treating seeds with fungicide such as thiram before sowing. If seedlings a few days old are found dying, watering must be reduced immediately and the seedlings must be drenched with metalaxyl or another suitable fungicide. Soft rot (*Erwinia* sp.) may become serious if the crop is left too long in the field. Pak choi is very susceptible to clubroot (*Plasmodiophora brassicae*).

Diamond-back moth (*Plutella xylostella*) and aphids are the major insect pests. Control of diamond-back moth is difficult because of its resistance to insecticides. At present, integrated pest management (IPM) networks are being set up by international agencies to control this pest. Aphids can be controlled by insecticides such as Pirimicarb.

Harvesting Harvesting may take place as early as 3 weeks after planting but usually takes place between 30–45 days, depending on the cultivar and the planting method. It can be done in succession when incorporated with thinning. If pak choi is left growing too long in the field it deteriorates quickly. Diseases such as soft rot may become a problem and tropical cultivars may bolt, which reduces marketability. Harvesting at the hottest part of the day should be avoided.

Yield The yields are 10–20 t/ha for the small plant type cultivars and 20–30 t/ha for the large cultivars.

Handling after harvest The succulent tender plants easily suffer from mechanical damage, withering and post-harvest diseases. They therefore cannot withstand long-distance transportation and prolonged storage. Upon harvesting the plants are washed, the small outer and senescent leaves are trimmed and the roots are removed. The clean plants are graded according to size and quality, such as degree of pest damage, bolting, deformation and etiolation. They are then packed in strong rigid containers with holes at the sides to avoid squashing and transpiration heat (e.g. plastic baskets of 72 cm length × 47 cm width × 33 cm height to hold 30 kg). The plants are packed with their base to the sides of the baskets, and their turgidity is maintained by lining the basket with a layer of paper.

Genetic resources Germplasm base collections of pak choi are maintained at the Institute of Horticultural Research, Wellesbourne, United Kingdom and the National Institute of Agrobiological Research, Tsukuba, Japan. The Asian Vegetable Research and Development Centre, Tainan, Taiwan, maintains a working collection with accessions collected from South-East Asia. A great amount of genetic diversity still occurs in southern and central China. The variation in South-East Asia is disappearing because only the few most popular cultivars are being contract-multiplied in Australia, China, Denmark, the Netherlands and the United States.

Breeding Breeding is concentrated on the purification of the few remaining local landraces to obtain better uniformity, higher yield and early maturation. Another important objective is to breed for wider adaptation to the wet lowland tropics. In China, Japan and Taiwan, F_1 cultivars of the short green petiole type are being aimed at.

Prospects The recent wave of East Asian emigrants to the West and Australasia has created a new demand for this group of vegetables. Non-oriental people are becoming acquainted with this vegetable too.

Interbreeding of the different cultivar groups will create new types to suit various requirements. Germplasm is currently being systematically collected in South-East Asia and China.

Literature |1| Cao, Shou-chun & Li, Shi-jun, 1980. A preliminary study on the local variety of Chinese cabbage (Brassica chinensis L.) I. Morphological observation and study. Journal of the Nanjing Agricultural College 2: 1–13. |2| Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 190–205. |3| Li, Chia-wen, 1984. Chinese cabbages of China. Agricultural Publishing Company, Beijing, China. 234 pp. |4| Lin, Weishen, 1980. A study on the classification of Chinese cabbages. Acta Horticulturae Sinica 7: 21–28. |5| Tay, C.S.,

1987. Characterization and evaluation work at AVRDC: an example with Brassica campestris. IBPGR Regional Committee for South-East Asia Newsletter, Special Issue: 55–65.

D.C.S. Tay & H. Toxopeus

Canavalia gladiata (Jacq.) DC.

Prodromus 2: 404 (1825).

LEGUMINOSAE

$2n = 22, 44$.

Synonyms *Dolichos gladiatus* Jacq. (1787), *Canavalia ensiformis* (L.) DC. var. *gladiata* (Jacq.) Kuntze (1898), *C. ensiformis* auct. non (L.) DC.

Vernacular names Sword bean (En). Pois sabre (Fr). Indonesia: kara pedang, kacang parasman, koas bakol. Malaysia: kacang parang, kacang polong. Philippines: habas (Tagalog), magtambokau (Bisaya). Cambodia: tioeuhs. Laos: (khùa) 'khao 'khièo. Thailand: thua-phra. Vietnam: d[aaj]u r[uwj]a.

Origin and geographic distribution Sword bean is of Asiatic or African origin. It is only known in cultivation and is probably derived from *C. virosa* (Roxb.) Wight & Arnott, the most closely related wild species, occurring mainly in Africa. Sword bean is widely cultivated in South and South-East Asia, especially in India, Sri Lanka, Burma and Indo-China. It has now spread throughout the tropics and has become naturalized in some areas.

Uses Sword bean is used as vegetable, cover crop, forage and green manure. The young green pods are extensively eaten in tropical Asia, served as a boiled green vegetable similar to common bean (*Phaseolus vulgaris* L.). The full-grown but still fresh, green seeds are consumed as a cooked vegetable similar to broad bean (*Vicia faba* L.). Sword bean is not a popular pulse because of the strong flavour and the thick, tough seed-coat. Dry, fully mature seeds should be eaten with caution as they may be somewhat poisonous. Detoxification by changing the cooking water, soaking, rinsing or fermentation is possible but laborious. White seeds are considered to have a better flavour than coloured seeds.

Both the flowers and young leaves are used steamed as a flavouring. In Java sword bean is used as a short-duration cover crop and as a green manure. It is occasionally used as fodder but less so than the related jack bean (*C. ensiformis* (L.) DC.). Pink seeds are sometimes employed in traditional Chinese medicine. The urease extracted from sword beans is used in analytical laboratories.

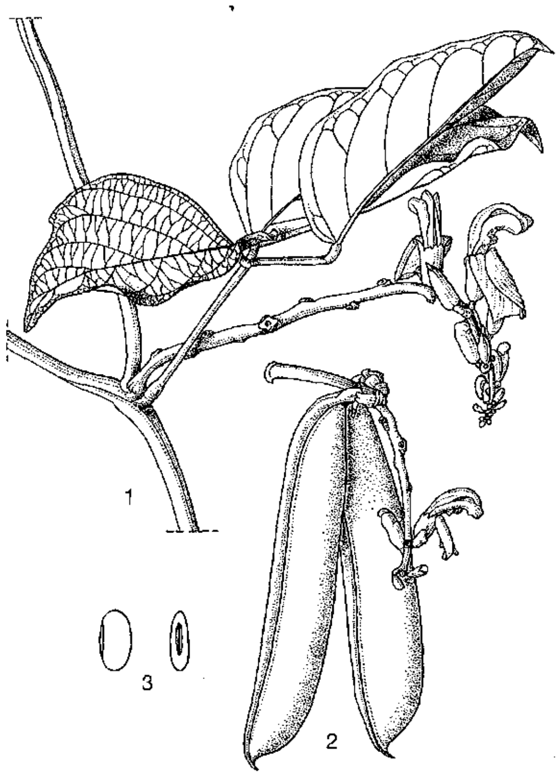
Production and international trade Sword bean is a small-scale vegetable crop, the fresh product being home-consumed or marketed locally. The dry, mature seeds are not an important product of commerce.

Properties The young green pods and the unripe fresh seeds are rather similar in composition and contain per 100 g edible portion: water 88.6 g, protein 2.7 g, fat 0.2 g, carbohydrates 6.4 g, fibre 1.5 g, ash 0.6 g, vitamin A 40 IU. The energy value is 160 kJ/100 g.

The use of sword bean is limited because of the growth-inhibiting compounds canavalin, concanavalin A and B, urease and canavanine. Toxicity seems largely due to concanavalin A, which binds to mucosal cells of the intestine, thus reducing the body's ability to absorb nutrients from the intestine.

1000-seed weight is 1000–4000 g.

Description A vigorous, woody, perennial



Canavalia gladiata (Jacq.) DC. – 1, flowering shoot; 2, young fruits; 3, seeds.

climber, 3–10 m long, often grown as an annual. Root system deeply penetrating the soil. Leaves trifoliolate, petiole 5–17 cm long, petiolules 4–7 mm; leaflets ovate, 7.5–20 cm × 5–14 cm, acuminate, sparsely pubescent on both surfaces. Inflorescence an axillary raceme, 7–12 cm long, peduncle 4–20 cm long, pedicels 2 mm long; flowers often reflexed; calyx up to 16 mm long; standard ca. 3.5 cm long, white. Fruit a legume, linear-oblong, slightly compressed, 15–40 cm × 2.5–5 cm, widest near the apex, sometimes curved with strongly developed ridges, containing 8–16 seeds. Seeds oblong-ellipsoid, strongly compressed, 2–3.5 cm × 1.5–2 cm, pink, red, reddish-brown to almost black, rarely white; hilum 1.5–2 cm long, dark brown; seed-coat very tough and thick.

Growth and development Sword bean seed germinates readily and the plant is relatively fast-growing. The flowers are visited by bees and 20% or more cross-pollination occurs. Young pods for vegetable use are available 3–4 months after sowing, mature seeds can be harvested 5–10 months after sowing.

Other botanical information Cultivars vary widely, particularly in the degree of twining, the size of the pods and the number and colour of the seeds. In some areas semi-erect forms are found. Forms with red or reddish to blackish seeds are sometimes classified as *C. gladiata* var. *gladiata* and forms with white seeds as var. *alba* (Makino) Hisauchi.

C. gladiata is often confused with *C. ensiformis* because their vegetative parts and flowers are very similar. However, they can be distinguished by their pods and seeds. In *C. ensiformis* the pod is usually more than 8 times as long as broad (in *C. gladiata* less than 8 times), and the hilum is less than half the length of the seed (in *C. gladiata* more than half the length of the seed). *C. ensiformis* is of New World origin.

Ecology Sword bean requires a tropical climate. It grows well at temperatures of 20–30°C and is cultivated from sea-level up to 1000 m altitude. Its deep root system allows sword bean to survive dry conditions, but it fares best with an evenly distributed rainfall of 900–1500 mm/year. It grows well on the very leached, nutrient-depleted, lowland tropical soils and on acid soils with a pH of 4.5–7.0. It is more resistant to saline soils and less affected by waterlogging or drought than many other legumes. It also tolerates some shade.

Agronomy Sword bean is usually grown near houses and allowed to trail on walls, fences and trees. It is propagated by seed, sown at a depth of 5–7.5 cm, at seed rates of 25–40 kg/ha. Plants are usually spaced 45–60 cm apart, in rows 75–90 cm apart. Sword bean is rather resistant to attack from diseases and pests. The most serious fungal disease is root rot (*Colletotrichum lindemuthianum*). Major pests are fall army worm (*Spodoptera frugiperda*) and beetle grubs that bore into the stems. At the end of the season, the crop should be dug up and burned. If grown as a perennial it is recommended that plants are kept not more than two years.

Green pods are normally hand-picked when they are 10–15 cm long, before they swell and become fibrous and tough. Mature pods are also harvested by hand to avoid shattering. Yields of green pods may reach 4 t/ha. Experimental yields as high as 4600 kg/ha of dry seed have been recorded, but farm yields average 700–900 kg/ha. Yields of green matter for forage are 40–50 t/ha. Stored seeds are rather resistant to infestation by pests.

Genetic resources and breeding There are no breeding programmes for sword bean. Some cultivars which show reduced toxicity have been selected. However, a programme for worldwide collection of germplasm is needed, followed by mass screening for cultivars containing no concanavalin A and other toxic constituents.

Prospects Sword bean is a minor vegetable crop and its use for human as well as animal consumption requires caution. The presence of toxic substances makes it unlikely that this bean will increase much in importance in the short term. However, because of its uncommon adaptability to adverse conditions, resistance to diseases and pests, and relatively high productivity, sword bean might be used as a reclamation crop on marginal lands, and therefore deserves more research attention.

Literature |1| Duke, J.A., 1981. Handbook of legumes of world economic importance. Plenum Press, New York/London, United States/United Kingdom. pp. 41–43. |2| Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 233–236. |3| Kay, D.E., 1979. Food Legumes. TPI Crop and Product Digest No 3. Tropical Products Institute, London, United Kingdom. pp. 365–370. |4| National Academy of Sciences, 1979. Tropical legumes, resources for the future. National Academy of Sciences, Washington, D.C., United States. pp. 54–59. |5| Nguyên van Thuân, 1979. Légumineuses – Papilionoïdées, Phaséolées. Canavalia. In: Flore du Cambodge, du Laos et du Vietnam [Flora of Cambodia, Laos and Vietnam] (various editors). Muséum National d'Histoire Naturelle, Laboratoire de Phanérogamie, Paris, France. Vol. 17. pp. 71–77.

G. Kooi

Capsicum L.

Sp. pl.: 188 (1753); Gen. pl. ed. 5: 86 (1754).
SOLANACEAE
$x = 12$; $2n = 24$ (*C. annuum, C. frutescens*)

Major species and synonyms
- *C. annuum* L., Sp. pl.: 188 (1753).
- *C. frutescens* L., Sp. pl.: 189 (1753).

Vernacular names Capsicum pepper, chilli, bird pepper, bird's eye chilli (En). Hot pepper, chile, paprika, sweet pepper, bird pepper (Am). Piment, poivron (Fr). Indonesia: lombok, cabai, cabai keriting, cabai rawit, cabai besar. Malaysia: cili, cili padi, cili api, cili sayur. Papua New Guinea: kapsikam, lombo. Philippines: sili, pasete. Cambodia: mo-tééhs phlaôk, mo-tééhs khmeang. Laos: ph'ik, phéd. Thailand: phrik. Vietnam: [ows]t.

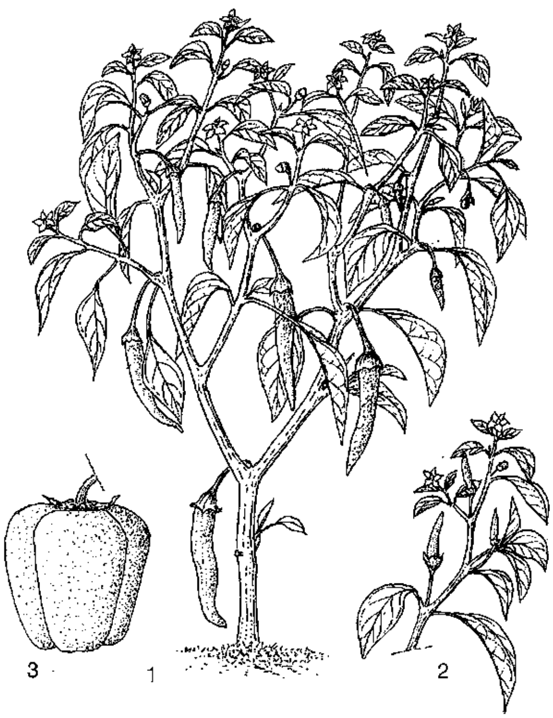
Origin and geographic distribution The genus *Capsicum* is of New World origin. It comprises 5 domesticated and about 25 wild species. Mexico is believed to be the centre of origin of *C. annuum*, whereas *C. frutescens* and the other cultivated species (*C. baccatum* L. var. *pendulum* (Willd.) Eshbaugh, *C. chinense* Jacq., and *C. pubescens* Ruiz & Pavón) originated in South America. Capsicum peppers were introduced to Asia in the 16th Century by Portuguese and Spanish explorers via trade routes from South America. Widespread geographic distribution of *C. annuum* and *C. frutescens* has occurred on all continents, whereas the others are little distributed outside South America. Capsicum peppers are cultivated throughout South-East Asia, the pungent forms having the greatest distribution and importance.

Uses Capsicum pepper is the most popular and most widely used condiment all over the world. Its fruits are consumed in fresh, dried or processed form as table vegetable or spice. Capsicum peppers are extensively pickled in salt and vinegar. Colour and flavour extracts are used in both the food and feed industries, e.g. ginger beer, hot sauces and poultry feed, as well as for some pharmaceutical products. In the Philippines and Indonesia, the shoot tips are cooked and used as condiment or vegetable. Sweet, non-pungent capsicum peppers are widely used in the immature, green-mature or mature-mixed-colours stage as a vegetable, especially in the temperate zones.

Production and international trade World production of capsicum peppers is estimated at 9.1 million t from 1.1 million ha. These figures, however, do not include production for home consumption and production for dried fruits, which constitute a significant part of the production in Asia. Regional statistics estimate production (fresh weight basis) for Asia alone at 8 million t from 1.6 million ha, with India, China, Indonesia and Korea having the largest areas in production. For South-East Asia the following statistics are available (1988–1992): Indonesia: 440 000 t from 137 000 ha; Malaysia: 21 000 t from 1685 ha; Philippines: 3625 t from 1450 ha; Thailand: 328 000 t from 121 000 ha. Although Thailand has been a major supplier of capsicum peppers in the region, its imports have exceeded exports in recent years. Malaysia exports a large volume of fresh peppers to Singapore, but imports dried peppers as well from India, China and Korea. Despite the large acreage grown in Indonesia, yields are low and small quantities must still be imported.

Properties The pungent principles of capsicum peppers are capsaicinoids (alkaloids) and are found in variable quantities (0.01–1.0% of dry weight) in the cross-walls and placental tissue. Mature fruits are rich in pigments such as carotenoids and xanthophylls. Per 100 g edible fresh portion, hot capsicum pepper contains: moisture 86 g, protein 1.9 g, fat 1.9 g, carbohydrates 9.2 g, Fe 1.2 mg, Ca 14.4 mg, vitamin A 700–21 600 IU, vitamin C 242 mg. The energy value is 257 kJ/100 g. For sweet capsicum pepper: moisture 92 g, protein 1.2 g, fat 0.35 g, carbohydrates 5.4 g, Fe 0.6 mg, Ca 9.0 mg, vitamin A 420–5700 IU, vitamin C 163 mg. The energy value is 109 kJ/100 g. The 1000-seed weight is 4–8 g.

Description
- *C. annuum*: a very variable, normally annual herb or subshrub, 0.5–1.5 m tall, erect, much branched, grown as an annual. Taproot strong, lateral roots numerous. Stem irregularly angular to subterete, up to 1 cm in diameter, much branched, often tomentose near branchings, green to brown-green, often with purplish spots near nodes. Leaves alternate, simple, very variable; petiole up to 10 cm long; leaf-blade ovate, up to 10(–16) cm × 5(–8) cm, acuminate at apex, margin usually entire, subglabrous, light to dark green. Flowers usually borne singly, terminal; pedicel up to 3 cm long in flower, up to 8 cm long in fruit; calyx cup-shaped, persistent and enlarging in fruit, usually with 5 conspicuous



Capsicum annuum L. – 1, flowering and fruiting plant; 2, shoot with upright fruits; 3, sweet pepper fruit.

teeth; corolla campanulate to rotate with 5–7 lobes, 8–15 mm in diameter, usually white; stamens 5–7 with pale blue to purplish anthers; ovary 2(–4)-locular, style filiform, white or purplish, stigma capitate. Fruit a non-pulpy berry, very variable in size, shape, colour, and degree of pungency, usually more or less conical, up to 30 cm long, green, yellow, cream or purplish when immature, red, orange, yellow, brown when mature. Seed orbicular, flattened, 3–4.5 mm in diameter, ca. 1 mm thick, pale yellow.

- *C. frutescens*: perennial subshrub, usually living 2–3 years. Structure similar to *C. annuum* but with usually 2 or more pedicels at a node and flowers with waxy greenish-white corolla; fruit usually upright, usually small and narrow, up to 5 cm × 1 cm, extremely pungent, green to cream or yellow when immature, orange to red when mature.

Growth and development Seeds germinate in 6–21 days after sowing and continuous flowering begins at 60–90 days after sowing. Flowers are open for 2–3 days. Although normally considered a self-pollinated crop, outcrossing up to 91% may occur, depending on bee activity and heterostyly. Under normal circumstances ca. 40–50% of the flowers set fruit. Fruits begin to mature at 4–5 weeks after flowering, and can be picked in sequences of 5–7 days. The peak harvest period is 4–7 months after sowing, but perennial growth continues in the absence of frost or disease.

Other botanical information Although it is general practice to consider *C. annuum* and *C. frutescens* as two different species, many intermediate forms occur which are difficult to identify as one of the two. Therefore, sometimes both species are united into one species *C. annuum* s.l. In the literature, the rich variation of C. *annuum* s.s. has mainly been classified according to fruit shape, but there is no satisfactory cultivar group classification. Until a better system is proposed, it seems best to follow the system of Irish who distinguished seven botanical varieties, now often considered as cv. groups:

- cv. group Abbreviatum: fruits ovate, wrinkled, 2–5 cm long. Also called Wrinkled Pepper.
- cv. group Acuminatum: fruits slender, curved, up to 11 cm long, mild to extremely pungent. Also called Chilli.
- cv. group Cerasiforme: fruits globose with firm flesh, up to 2.5 cm in diameter, mild to pungent, red, yellow or purple. Also called Cherry Pepper or Bird's Eye Pepper.
- cv. group Conoides: fruits subconical, up to 3 cm long, very pungent. Also called Cone Pepper.
- cv. group Fasciculatum: fruits clustered, erect, up to 7.5 cm long, very pungent. Also called Cluster Pepper.
- cv. group Grossum: fruits large with basal depression, inflated, red, orange, yellow, or purple, flesh thick and mild. Also called Sweet Pepper or Paprika.
- cv. group Longum: fruits drooping, up to 30 cm long, mild or pungent, red, yellow or whitish. Also called Long Pepper.

Some well-known *C. annuum* cultivars in Indonesia are 'Jatilaba', 'Tit', 'Super', 'Paris' and 'Tampar'. Within *C. frutescens* all cultivars are extremely pungent and no cv. groups are distinguished. It also comprises Bird Peppers or Bird's Eye Peppers. Some Indonesian cultivars are 'Jempling', 'Jemprit', and 'Mentek' and 'Rawit'. Farmers use different cultivars for low and high elevations.

Common cultivars of the Acuminatum group in Malaysia are 'Kulai', 'Langkap', 'Bukir Gambit', 'Tanjung Minyak', 'MC4' and 'MC5'. The bird's eye chillies are commonly referred to as 'Cili Padi' and

'Cili Burung'. Bird's eye chillies are the most popular types grown in Papua New Guinea. In Thailand, common cultivars of the Acuminatum group are 'Bang Chang', 'Yuak' (waxy yellow-green), 'Luang' (orange-mature), 'Mun', 'Chee Fah' and 'San Pa Thong' to name a few. 'KKU Cluster' and 'Chau Mankau' belong to the Fasciculatum cultivar group. 'Huay Sithon' is a very popular cultivar in the Conoides group with fruits up to 5 cm. In the Philippines, sweet capsicum peppers are more commonly grown than pungent capsicum peppers. Besides some imported cultivars like 'California Wonder' and 'Yolo Wonder' the few local sweet capsicum cultivars are 'All Season', 'Sinagtala' and the hybrid 'Annabelle'. Local cultivars of pungent capsicums are 'Matikas', 'Kawit', 'Bontoc' and 'Hot Shot'. A cultivar of the small pungent Conoides group is 'Pacete'.

Ecology Capsicum peppers are considered to be warm season, day-neutral plants, although certain forms may show a photoperiodic reaction. The vegetative cycle may be hastened by imposing certain photoperiods, but reports in the literature are conflicting. Capsicum peppers tend to tolerate shade conditions up to 45% of prevailing solar radiation, although shade may delay flowering. Capsicum peppers grow best on well-drained loamy soils at pH 5.5–6.8. They grow at a wide range of altitudes, with rainfall between 600–1250 mm. Severe flooding or drought is injurious to most cultivars. Seeds germinate best at 25–30°C. Optimal temperatures for productivity are between 18–30°C. Cooler night temperatures down to 15°C favour fruit setting, although flowering will be delayed as temperatures drop below 25°C. Flower buds will usually abort rather than develop to maturity if night temperatures reach 30°C. Pollen viability is significantly reduced at temperatures above 30°C and below 15°C.

Propagation and planting Capsicum peppers are propagated by seed. Seeds should be harvested from mature fresh fruits after 2 weeks of post-harvest ripening. Seeds remain viable for 2–3 years without special conservation methods if kept dry, but they rapidly lose viability if improperly stored at high temperature or humidity. Seed dormancy may occur to a limited extent, especially if seed is harvested from under-ripe fruits. Seed priming treatments are sometimes effective in invigorating germination. To plant 1 ha, 200–800 g of seed is needed depending on plant density. In Asia seeds are usually sown shallow in nursery beds or flats, and transplanted bare-rooted to the field. Seed-beds are usually covered with straw, leaves or protective tunnels. For better production, seedlings should be transferred to seedling pots (plastic pots, paper cups, banana leaf-rolls, etc.) when the cotyledons are fully expanded. In the nursery, starter fertilizer is recommended at 2-week intervals. Transplants are planted out in the field at the 8–10 true leaf stage, usually 30–40 days after sowing. Hardy transplants can be produced by restricting water and removing shade protection, starting 4–7 days before transplanting. Transplanting should be done during cloudy days or in the late afternoon, and should be followed immediately by irrigation. Direct sowing in the field is practised to a limited extent. Plant populations may range from 10 000–130 000 plants per ha, depending on the region, management practices, and cultivar. Capsicum peppers are well adapted to sole cropping and intercropping systems. In Asia, production is usually practised on small-scale farms on plots of 0.1–0.5 ha, although total acreage may be substantial. Capsicum peppers are often relay-cropped with tomatoes, shallots, onions, garlic, okra, *Brassica* spp. and pulses. They also grow well among newly established perennial crops.

Husbandry Capsicum peppers thrive best if supplied with liberal quantities of organic matter and a balance of mineral fertilizers. A reasonable recommendation is to supply 10–20 t/ha of organic amendments. General nutrient requirements are 130 kg/ha of N, 80 kg/ha of P and 110 kg/ha of K, split into basal plus side dressings at 3–4-week intervals, beginning at first flowering. Boron at the rate of 10 kg/ha is also recommended. Nutrient availability is subject to soil type and environmental conditions, so local recommendations vary. In Asia, manual weeding is the common practice for weed control. It is most critical at the reproductive phase. Organic or plastic mulches are very effective for weed control, and reflective mulches help to minimize insect vectors of plant viruses. Staking is not a common practice in most of Asia, but may help to minimize lodging. Capsicum peppers may be grown under rainfed or irrigated conditions. To avoid certain diseases, pests or allelopathic damage, capsicum peppers should not be planted after other solanaceous crops, sweet potato or jute.

Diseases and pests Viruses cause the most serious damage. The most obvious method of control is to use resistant cultivars. Unfortunately only few cultivars with virus resistances are known. Cucumber mosaic virus (CMV), chilli veinal mottle virus (CVMV), potato virus Y (PVY) and a complex of the tobamovirus group are the most important in Asia. Anthracnose caused by *Colletotrichum* spp. is a major problem of ripened fruits and is best controlled by proper crop management to minimize the source of inoculum via seeds or host debris. Partial resistance has been found. *Phytophthora* blight and crown rot (*P. capsici*), *Cercospora* leaf-spot (*C. capsici*), bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) and bacterial wilt (*Pseudomonas solanacearum*) are other important diseases and are best controlled by integrated pest management, including resistant cultivars that may be available. The major pests are thrips, aphids, mites, bollworms (*Heliothis* spp.), and fruit flies (*Dacus* spp.). As most of these are polyphagous pests, control is difficult. Resistances are not yet available, but field tolerance is observed in some cultivars and landraces. Inappropriate pesticides and over-use of pesticides often augment the pest problems on capsicum peppers. Integrated crop management is suggested to overcome multiple pest and disease problems.

Harvesting Capsicum peppers are ready for harvest 3–6 weeks after flowering depending on the fruit maturity desired. Green fruits are mature when firm; if gently squeezed they make a characteristic popping sound. Harvesting is done by hand or with the aid of a small knife. Sweet capsicum peppers are often harvested at the green mature stage, although sometimes they are harvested red. Assorted fruit colours such as yellow, orange, chocolate and purple are also available in specialized markets. Hot capsicum peppers are harvested green or red depending on their utilization. For the fresh market, fruits are harvested mature but firm, whereas capsicum peppers sold as dried pods may be left to partially dry on the plants before harvesting.

Yield Capsicum pepper yields vary widely from 1.5–18 t/ha, particularly in Asia. Maximum dry weight recovery of hot capsicum peppers is near 25–30%. Yields under irrigated conditions tend to be higher than for rainfed production, but vary with other management practices.

Handling after harvest Unless sold for the fresh market, hot capsicum peppers are sun-dried in most of Asia. Sun-drying usually takes place in a vacant field or roadside, on mats or a well-swept area. In the sun, capsicum peppers will dry adequately in 10–20 days, with frequent turning of fruits. Steaming of hot capsicum pepper before being sun-dried is normally practised in southern Thailand. It tends to improve the appearance, making dried fruits look glossy. Marketing is usually conducted from wholesale to retail markets, but there are also many informal marketing channels. Dried capsicum peppers may be stored for months in wholesale warehouses to supply year-round demands. Fresh fruits can be stored for up to 5 weeks at 4°C and 95% humidity.

Genetic resources There are a number of working collections of *Capsicum* germplasm. The largest is at the Asian Vegetable Research and Development Center in Taiwan, which was targeted as a global back-up for other base and working collections. Near major production areas and centres of genetic diversity, many regional collections exist. A fine collection of wild species is maintained at the Universidade Federal in Viçosa, Brazil.

Breeding Breeding for disease resistance takes precedence in most programmes, although yield, abiotic stress tolerance, earliness and quality in pungency, flavour and colour are overall objectives for capsicum pepper improvement in the tropics. The cultivars in Asia are mostly open-pollinated and farmers tend to save and plant their own seed. National programmes and private seed companies play a role in supplying quality seed stocks and improved cultivars. There is some interest in the promotion of hybrid cultivars, produced by hand emasculation and pollination or through the use of male sterility.

Prospects Capsicum peppers have a high nutritional and economic value and are adapted to an array of production and marketing systems. Production can only be promoted if seed quality and supply are guaranteed. Efforts to improve seed production, storage and distribution systems will strongly influence the adoption of suitable cultivars.

Literature |1| Abd. Jabar, K., Othman Y. & Paramanathan, S., 1984. Fertilizer requirement of chilli. In: Mohammad Md. Ali & Lim Eng Siong (Editors). Proceedings of the symposium on vegetables and ornamentals in the tropics, October 27–28, 1982. Agricultural University of Malaysia, Serdang, Selangor, Malaysia. pp. 85–88. |2| Andrews, J., 1984. Peppers: the domesticated Capsicums. University of Texas Press, Austin, Texas, United States. 170 pp. |3| AVRDC, 1989. Tomato and pepper production in the tropics. Proceedings of the international symposium on integrated management practices, March 21–26, 1988. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. 619 pp. |4| Bosland, P.W., Bailey, A.L. & Inglesias-Olivas, J.,

1990. Capsicum pepper varieties and classification. New Mexico State University Cooperative Extension Service Circular 530, College of Agriculture and Home Economics, Albuquerque, United States. 13 pp. |**5**| IBPGR, 1983. Genetic resources of Capsicum. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 49 pp. |**6**| Irish, H.C., 1898. A revision of the genus Capsicum with special reference to the garden varieties. Annual Report of the Missouri Botanical Garden 9: 53–110. |**7**| Martin, F.W., Santiago, J. & Cook, A.A., 1979. Vegetables for the hot, humid tropics. Part 7. The peppers, Capsicum species. Agricultural Research Science and Education Administration. United Sates Department of Agriculture, New Orleans, United States. 18 pp. |**8**| Rylski, I., 1985. Capsicum. In: Halevy, A.H. (Editor): Handbook of flowering. Vol II. CRC Press, Boca Raton, Florida, United States. pp. 140–146.

J.M. Poulos

Chrysanthemum coronarium L.

Sp. pl.: 890 (1753).

COMPOSITAE

$2n = 18$; 36 (tetraploid)

Synonyms *Matricaria coronaria* (L.) Desr. (1792), *Pinardia coronaria* Lessing (1832), *Chrysanthemum spatiosum* L.H. Bailey (1949).

Vernacular names Garland chrysanthemum, crown daisy, tangho (from Chinese) (En). Shungiku (from Japanese), chop suey green, Japanese green (Am). Chrysanthème des jardins (Fr). Indonesia: tango, saruni walanda (West Java). Philippines: tango (Tagalog). Laos: tang 'ôô. Thailand: phaktang-o (central), phakkhikhwai (northern). Vietnam: c[ar]i c[us]c, c[us]c t[aaf]n [oo].

Origin and geographic distribution *C. coronarium* is native to the Mediterranean region and is distributed throughout Europe, northern Africa, and Asia. It has long been cultivated in Europe and Asia, but for different purposes: in the western world mainly as an ornamental, in Asia (China, Japan) mainly as a vegetable. In South-East Asia, the vegetable types were probably introduced from China relatively recently, as the Chinese-derived name 'tangho' has remained strongly associated with the crop in most countries.

Uses The aromatic leaves and young shoots of tangho have a spicy, slightly resinous, 'floral' taste. The Chinese and Japanese are especially fond of this vegetable. The small-leaf types have a very strong taste and are eaten cooked or fried, often together with other vegetables or in soups. The large-leaf types can in addition be eaten raw in salads. When the leaves are cooked too long, they become very bitter. The flowers are also edible. Usually only the petals are used, fresh or dried, as a garnish or to brew a tea. Tangho is also consumed in the form of seedling sprouts.
In Thailand, it is used as a medicinal plant to cure venereal diseases. *C. coronarium* or garland chrysanthemum is an old-fashioned ornamental in Europe. Special forms with double ray flowers, and larger-sized tetraploids ($2n = 36$?) have been developed.

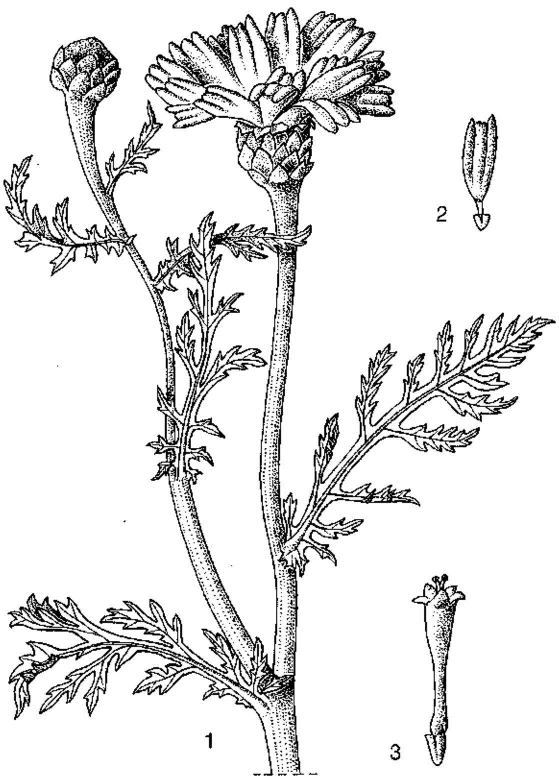
Production and international trade Tangho is one of the leading greens in East Asian countries (Japan, China, Taiwan) and is also very important in Indo-China. No production statistics from South-East Asia are available, but it is a common market garden vegetable. It is regularly offered in the assortment of fresh vegetables sold by supermarkets in South-East Asian countries.

Properties Per 100 g edible portion, tangho contains: water 90–94 g, protein 1.2–2.7 g, vitamin A 0.4–3.0 mg, vitamin B_1 0.15 mg, vitamin B_2 0.30 mg, vitamin C 17–45 mg, Ca 75 mg, Fe 2.7–4.2 mg. The weight of 1000 seeds is about 1.5 g.

Description An erect, densely leafy, branched, annual herb, 20–60 cm tall in the vegetative stage, up to ca. 90 cm when flowering. Leaves alternate, semi-amplexicaul, oblong to obovate in outline, 3–13 cm × 1–4 cm, variably incised from entire to 2-pinnatisect (most usual form) with oblong, lanceolate or linear, incise-dentate segments or lobes. Inflorescence a head, 3–6 cm in diameter; peduncle ribbed, 2–15 cm long; involucral bracts in 2–4 rows, margins scarious; ray flowers (marginal) 12–15, only female, ligule oblong, 1–1.5 cm × 5–8 mm, emarginate at apex, yellow; disk flowers (central) numerous, bisexual, with tubular corolla 4–5 mm long, yellow and 5-lobed at top. Fruit a glandular, more or less turbinate achene, 2–3 mm long, without pappus, in marginal flowers with 3 wings and 6-ribbed, in the central flowers with 1 wing and 10-ribbed.

Growth and development The seed normally germinates within 10 days of sowing. Tangho flowers readily in temperate as well as tropical regions. It is basically a self-pollinated crop, but considerable cross-pollination may occur by insects or wind.

Other botanical information Three types are usually distinguished based on the shape and the size of the leaves:



Chrysanthemum coronarium L. – *1, flowering shoot; 2, ray flower; 3, disk flower.*

- small-leaf type: closest to the wild type with thin, finely divided, light green leaves and a strong taste; it is early-flowering, not strongly branched, and therefore low-yielding, but widely adapted to cool as well as warm climates;
- large-leaf type: with thick, shallowly lobed or entire, dark green leaves and a mild taste; the plants are larger, strongly branched, high-yielding and adapted to warm climates;
- intermediate type: with moderately thick and moderately indented, dark green leaves; the plants are strongly branched, fast-growing, high-yielding and adapted to both cool and warm climates; this is the most popular type.

This classification is gradually becoming obsolete as the distinctions are being eroded by breeding and selection, and instead named cultivars are becoming important. In Taiwan and southern China, a type occurs with obovate, thick, unlobed leaves called 'Tiger Ear'; the leaves are tender and sweet and can be eaten raw like lettuce; it is not cold-resistant. There are special cultivars for ornamental use, which differ from the vegetable types in size and colour of the flowers.

Because of the enormous variability in leaf form, it becomes difficult to identify tangho always as *C. coronarium*. Typically *C. coronarium* has leaves that are 2-pinnatisect with linear lobes and the achenes of ligulate flowers bear an adaxial wing. It is possible that in the whole complex of tangho *C. segetum* L. (corn chrysanthemum) also is involved. This species is a rather common weed in Europe, northern Africa and western Asia, and its leaves are also edible. They are deeply incised-dentate, but never pinnatisect or linearly lobed and the achenes of its ligulate flowers are not adaxially winged.

Ecology Tangho grows best in cool temperate climates, but it does well at higher elevations in the tropics. Some cultivars even tolerate light frost. Temperatures should not exceed 25°C, as the crop will produce few leaves and will flower early.

Tangho seems to be photoperiod-insensitive, flowering readily at temperate and tropical latitudes. It grows relatively well at low light levels. It suffers from very wet conditions or heavy rainfall. Fertile, moisture-retentive soils are preferred, but tangho is not very demanding of soil type.

Agronomy Normally tangho is propagated by seed, but like most chrysanthemums propagation by cuttings from older plants is also possible. Cuttings will root within a month. Seed of good quality can be stored for 2 years or longer. Seeds are small and should be sown shallowly and only lightly covered afterwards. They can be broadcast or sown in rows directly in the field, or sown in a seed-bed or tray and transplanted when 3–4 cm high. Plant spacing depends on harvesting stage (seedlings or mature plants) and harvesting method (pulling or repeated cuts) but varies from 5–15 cm × 5–15 cm. Tangho is sometimes cultivated in plastic tunnels or under shelters during the rainy season.

Seedlings can be harvested 4–5 weeks from sowing when they are 5–10 cm tall. They can be pulled, or cut several times over a period of about one month. Alternatively, plants are harvested when they are vegetatively mature (15–25 cm high at 6–8 weeks from sowing) and either pulled or harvested by repeated cuttings over a 3-month period.

The top of the main stem is sometimes pinched out to promote branching, and it is recommended to remove flower buds as they form, because they negatively affect vegetative growth and taste.

Tangho is suitable for intercropping because it is

shade-tolerant. It is remarkably free from diseases and pests, and requires little care apart from weeding during early crop growth.
Like most leafy vegetables, tangho wilts rapidly after harvest. Refrigerated and wrapped in plastic, it stays fresh for two days.
In seed production, yields vary from 1300–2000 kg/ha.

Genetic resources and breeding There seem to be no major germplasm collections apart from breeders' working collections. Selection work on tangho is mainly carried out in Japan. New cultivars adapted to a wide range of climates and to new cultivation methods (e.g. hydroculture), are being bred.

Prospects Tangho is not a new crop in South-East Asia, but it has long been of minor importance as an ornamental or vegetable. The selection and commercialization of improved vegetable cultivars by Japanese and Taiwanese seed firms constitute a new impetus to its cultivation as a market garden vegetable.

Literature |1| AVRDC, 1988b. Gardening nutritious vegetables. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. 136 pp. |2| Buishand, T., Houwing, H.P. & Jansen, K., 1986. Groenten uit alle windstreken [Vegetables from all corners of the world]. Spectrum, Utrecht, the Netherlands. p. 42. |3| Chayamarit, K., 1984. Some medicinal plants of the family Compositae. Proceedings of the National Forestry Conference, November 19–23, 1984, Bangkok, Thailand. pp. 78–89. |4| Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 168–171. |5| Larkcom, J., 1991. Oriental vegetables. The complete guide for garden and kitchen. John Murray, London, United Kingdom. pp. 76–78, 136. |6| Shinohara, S. (Editor), 1984. Vegetable seed production technology of Japan. Shinohara's Authorized Agricultural Consulting Engineer Office, Tokyo, Japan. Vol. 1. pp. 175–184.

U.A. Dasuki & M.H. van den Bergh

Cichorium endivia L.

Sp. pl.: 813 (1753).
COMPOSITAE
$2n = 18$ (36)

Vernacular names Endive, escarole (En). Chicorée frisée, cichorée escarole (Fr). Indonesia: andewi. Philippines: endiba (Tagalog), eskarola (Bisaya). Thailand: phakkat-foi.

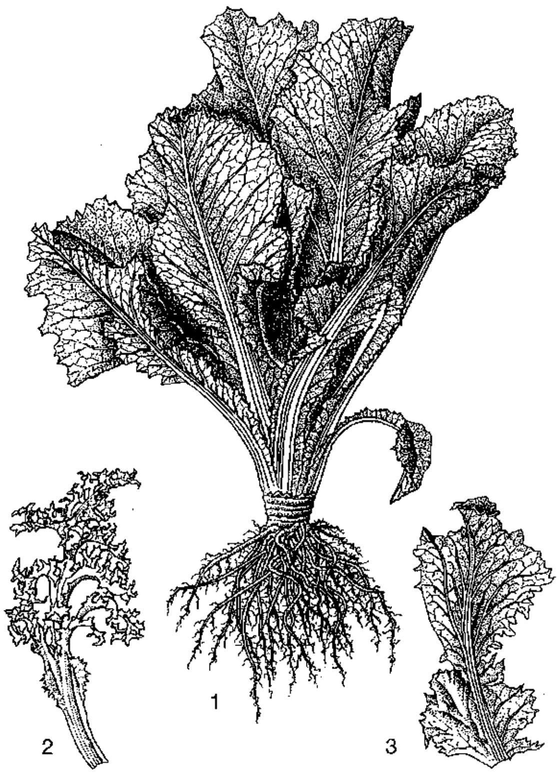
Origin and geographic distribution Endive was probably first brought into cultivation in the eastern Mediterranean, where its wild relative (*Cichorium endivia* ssp. *divaricatum* (Schousboe) P.D. Sell) still occurs. Endive (ssp. *endivia*) was known to the old Egyptians, spread to India at an early date and to Central Europe in the 16th Century. It is now grown throughout the world. In the tropics it is of some importance in the Philippines, Malaysia, Central and West Africa, and the Caribbean.

Uses Endive is most commonly eaten as a fresh green in salads, for which curly-leaved forms are preferred. Plants for salads are often blanched to reduce bitterness. Green plants and broad-leaved forms (escarole) are also used as a cooked vegetable. In Indonesia endive is eaten fresh or steamed as a side-dish with rice. It is sometimes used in making pickles ('asinan') but otherwise not used in a processed form.

Production and international trade The main area of production is the European Community with 530 000 t per year from 26 000 ha in 1985, followed by North America with about 50 000 t. No statistics are available for other areas.

Properties Endive contains per 100 g edible portion: water 95 g, protein 1.2–2 g, fat 0.2 g, carbohydrates 1–1.5 g, fibre 1 g, K 300 mg, Ca 20–80 mg, P 20–70 mg, Mg 14–20 mg, Fe 0.7–2 mg, vitamin A 1600–3200 IU, vitamin B 0.2 g, vitamin C 5–10 mg, niacin 0.4–0.5 mg. Endive contains inulin and intybin, which cause the typical bitter taste and which supposedly stimulate appetite. The 1000-seed weight is 1.3–1.6 g.

Description Annual, sometimes biennial herb containing bitter milky juice, producing a shortened stem with a rosette of large leaves when young. Rosette leaves alternate, sessile, thinly pubescent or glabrous, yellow or light to dark green, sometimes reddish along midrib; in escarole types, leaf-blade broadened, 10–25 cm × 8–15 cm, slightly crumpled, margin entire or dentate; in curly-leaved types, leaf-blade reduced, very narrow, deeply pinnatifid and strongly curled; both types form a loose head, usually creamy in the centre.
In the generative stage, endive produces an erect branched stem, 50–150 cm high, with progressively smaller leaves. Inflorescence a terminal or axillary head, 1–3 together, sessile or peduncled, blue-flowered; involucre with outer row of 5 bracts, and inner row of 8 bracts; flowers all ligulate, numerous; stamens 5 with anthers fused. Fruit an obovate achene, 2–3.5 mm × 1 mm, with pappus of



Cichorium endivia L. – 1, habit; 2, leaf of cv. group Curled Endive; 3, leaf of cv. group Escarole.

minute persistent membranous scales.

Growth and development Flowers usually open in the morning hours only and wither 6 hours later. Most cultivars are self-pollinating, but some cross-pollination caused by insects is normal.

Other botanical information Up to now it is common practice in taxonomic literature to distinguish two subspecies: ssp. *endivia* for the cultivated taxa and ssp. *divaricatum* for the wild taxa. It seems best to classify the cultivated taxa directly in cultivar groups and cultivars. Three groups can be distinguished and are proposed here:

- cv. group Escarole (synonym: *C. endivia* L. ssp. *endivia* var. *latifolium* Lamk): with broad, almost entire, rather flat leaves, forming a loose head; some well-known cultivars are 'Batavian Broad-Leaved', 'Escarole', 'Deep Heart Fringed' and 'Growers Giant'.
- cv. group Curled Endive (synonym: *C. endivia* L. ssp. *endivia* var. *crispum* Lamk): with narrow, deeply pinnatifid, strongly curled leaves, forming a loose head; some well-known cultivars are: 'Salad King', 'Green Curled' and 'Green Curled Ruffic'.
- cv. group Small Endive (synonym: *C. endivia* L. spp. *endivia* var. *endivia*): with very small leaves which do not form a head; this group is hardly grown anymore.

Ecology Endive is an easy to cultivate vegetable. It is more tolerant of high temperatures than lettuce and can be grown from cool temperate areas to tropical lowlands, though in the tropics better results are obtained above 500 m. The mean daily optimum temperature for growth is 15–18°C. Endive tolerates only light frost. At high temperatures leaves may become fibrous.

Endive requires long days for flowering and rarely flowers in the tropics. Vernalization (at temperatures below 15°C) gives an additional stimulus to flowering and can occur during ripening of the seed, storage of seed and from sowing onwards.

Endive prefers a loose, pervious soil, sufficiently fertile, especially in the top 20 cm, with a pH of 6.5–7.8.

Agronomy Cultivation of endive is similar to that of lettuce, but generally less demánding. It requires a deeply tilled soil and a friable seed-bed. It is propagated by seed. If sown in a seed-bed, seedlings are transplanted about 1 month after sowing, when they have 4–6 leaves. Direct sowing is practised as well. The planting distance is 25–40 cm × 25–40 cm, with the widest spacings for the broad-leaved cultivars. Dense planting favours self-blanching, but increases the risk of rot.

Nitrogen requirements of endive are moderate, heavy applications leading to strongly increased nitrate contents in the leaves and increased susceptibility to rotting. Phosphate requirements are high, those of potassium moderate, a crop of 12 t removing about 20 kg of P_2O_5 and 45 kg K_2O. Mg deficiency may occur on acidic soils or where ample potassium is available, but can be corrected by spraying a 2% solution of magnesium sulphate.

An irregular supply of moisture may cause discolouration of the edges of younger leaves. Endive does not tolerate waterlogging.

Diseases and pests are rarely serious in endive. *Botrytis cinerea*, *Sclerotinia* spp. and various bacteriae may cause 'bottom rot' (rot of the base of the plant), *Marssonina panattoniana* and *Alternaria cichorii* can cause leaf-spot, *Bremia lactucae* downy mildew. Aphids, larvae of Noctuidae and various caterpillars may cause damage. Endive should not be planted after pulses, carrots, potatoes, garden beets and other composite crops, be-

cause of possible nematode build-up.
Endive matures in 60–90 days from sowing. About a week before harvesting, heads are often tied up in order to blanch them and to moderate the bitterness of the product. Blanching can also be achieved by covering each plant with a pot or container to exclude light (for about 10 days). There are self-blanching cultivars (especially when densely planted). Harvesting can start when heads have reached a marketable size (250–400 g). It is done by cutting the heads from the roots, removing the outer, discoloured or damaged leaves and placing the heads upside down in containers. Yields per ha can reach 20 t of marketable produce per crop.
At ambient temperatures endive can be stored for only 1 day. When cooled to 0–1°C and at a humidity of 90–95%, healthy heads can be stored for up to 2 weeks.

Genetic resources and breeding Small collections of germplasm are kept by commercial breeders, at the Institut für Pflanzenbau und Pflanzenzüchtung, Braunschweig, Germany, and at the Vegetable Production Research Unit, USDA, Salinas, California. Very little breeding work is done. Commercial seed production is concentrated in Mediterranean countries.

Prospects Endive has a place in western cuisine in the tropics, where it often replaces lettuce in salads. Its relative ease of cultivation, bolt resistance and the availability of self-blanching cultivars favour its continued cultivation.

Literature |1| Krug, H., 1991. Gemüseproduktion [Vegetable production]. 2nd edition. Verlag Paul Parey, Berlin, Germany. pp. 463–466. |2| Nonnecke, I.L., 1989. Vegetable production. Van Nostrand Reinhold, New York, United States. pp. 466–472. |3| PAGV, 1987. Teelt van andijvie [Cultivation of endive]. Teelthandleiding 22. Proefstation voor de Akkerbouw en de Groenteteelt in de Vollegrond (PAGV), Lelystad, the Netherlands. 52 pp. |4| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 82–84.

L.P.A. Oyen

Citrullus lanatus (Thunberg) Matsum. & Nakai

Cat. sem. et spor. Horto bot. Univ. imp. Tokyo 30: No 854 (1916).
CUCURBITACEAE
$2n = 22$

Synonyms *Momordica lanata* Thunberg (1794), *Citrullus vulgaris* Schrader ex Ecklon & Zeyher (1836), *Colocynthis citrullus* (L.) O. Kuntze (1891).

Vernacular names Watermelon (En). Pastèque (Fr). Indonesia: semangka, cimangko (Minahasa). Malaysia: tembikai, mendikai. Papua New Guinea: melon. Philippines: pakwan (Tagalog), sandiya (Bicol), dagita (Marinduque). Cambodia: 'öö'w llök. Laos: môô, tèèng môô. Thailand: taengmo (central), taeng-chin (peninsular), matao (northern). Vietnam: d[uw]a h[aa][us], d[uw]a d[or].

Origin and geographic distribution Watermelon originated from the drier, open areas of tropical and subtropical Africa. Its cultivation became widespread in the Mediterranean region at least 3000 years ago. Introduction into India must also have occurred in ancient times and here a strong secondary centre of genetic diversity developed. Watermelon reached China around the 10th Century and Japan in the 16th Century. From India and China it spread to South-East Asia in the 15th Century. It was introduced to the Americas in post-Columbian times. Watermelon is now widespread in all tropical and subtropical regions of the world.

Uses Most cultivars are grown for fresh consumption of the juicy and sweet flesh of mature fruits. In China and most countries in Asia large-seeded cultivars are grown for the oil- and protein-rich seeds, which are eaten after drying or roasting, with or without salt.
Other uses include sweet preserves and pickles from the rind of mature fruits (Philippines), fresh juice with salt and pepper (India), sweet syrup and beer (Russia), young fruits as ingredient in curries (India, Thailand). In Mediterranean countries, cultivars are grown as staple food for human and livestock consumption, while in Africa bitter-fruited watermelons are grown for the edible seeds. The seeds contain cucubicitrin, which has curative properties for kidney and urethral problems.

Production and international trade Annual world production is about 30 million t from 2 million ha. At least 50% is produced in Asia, the most important producing countries being China 325 000 ha, India 250 000 ha, Thailand 40 000 ha, Japan 26 000 ha, Taiwan 24 000 ha, South Korea 20 000 ha, Vietnam 16 000 ha, Philippines 10 000 ha, Malaysia 6000 ha and Indonesia 3000 ha. Other major watermelon producing countries in the world are the Commonwealth of Independent States 500 000 ha, Turkey 250 000 ha, Iran 115000 ha, United States 82 000 ha, Brazil 75 000 ha, Egypt 67000 ha and Mexico 37000 ha. Most watermelons are produced for local and urban markets, each country having its preferences for size and type. Production for export markets has developed in Spain and other Mediterranean countries, Japan and Taiwan, using smaller-fruited F_1 hybrid cultivars, including seedless types.

Properties The nutritional value of watermelon is low. The composition per 100 g edible portion (50–70% of the mature fruit) is: water 90 g, protein 0.7 g, fat 0.1 g, carbohydrates 9 g, vitamin A 300 IU, vitamin B_1 0.08 mg, vitamin B_2 0.02 mg, niacin 0.2 mg, vitamin C 6 mg, Ca 8 mg, Fe 0.2 mg, Mg 10 mg, P 14 mg. The energy value is approximately 150 kJ/100 g. On the other hand, the seeds are rich in protein (40 g per 100 g edible portion) and fat (43 g per 100 g). The weight of 1000 seeds is 40–70 g (100–140 g for seedy watermelon).

Description Monoecious, occasionally andromonoecious, spreading, annual vine. Root system extensive but shallow, consisting of taproot and many lateral roots growing in the top 50–60 cm of the soil. Stem thin, angular and grooved, 1.5–5 m long, with soft, long, white hairs. Leaves simple, alternate, oblong-ovate in outline, cordate at base, 5–20 cm × 2–19 cm, palmately deeply 3–5(–7)-lobed; lobes elongated-ovate in outline, pinnately sinuate-lobulate, shallowly sinuate-toothed, rarely subentire, with the central lobe the largest; petiole 2–14 cm long; tendrils simple to 2(–4)-fid. Flowers solitary, axillary, on long hairy pedicels, pale yellow in colour, 2–3 cm in diameter, usually in cycles of 6 staminate flowers followed by 1 pistillate flower; calyx 5-lobed and corolla 5-partite; male flowers with 3 free anthers on short filaments; female flowers with inferior, ovoid, hairy ovary and a short style terminated by a 3-lobed stigma; nectaries present in male and female flowers. Fruit an indehiscent pepo, globular to oblongoid or ellipsoid, up to 60–70 cm in length, weighing 1.5–30 kg; fruit-wall glabrous to hairy, thin to thick, brittle to tough and flexible, colour varying from creamy, golden-yellow, light green to dark green, uniform or mottled or striped; flesh derived from the placenta, mostly red or yellow but also pink, orange or white; flesh texture from finely grained and 'melting' to firm, coarse and fibrous. Seeds scattered throughout the flesh, numerous (200–900 per fruit), smooth, flattened, 6–15 mm × 5–7 mm × 2.5 mm, black, brown, red, yellow, rarely white, without endosperm.

Citrullus lanatus (Thunberg) Matsum. & Nakai – 1, flowering and fruiting shoot; 2, fruit.

Growth and development Watermelon seed will remain viable for at least 8 years when stored dry at temperatures below 18°C. Germination is epigeal with cotyledons unfolded within 10 days after sowing and the first true leaf appearing one week later. The first 2 to 3 true leaves are often not deeply lobed. Usually the main vine continues to grow for several nodes before the first lateral branch is formed. The first male flower appears on the 10–15th node and the first female flower some 7 nodes later. The first female flowers often have poorly developed ovaries and fail to set fruit. The flowering peak occurs 50–80 days after germination. Flowers open shortly after sunrise and remain open only one day. The pistillate flower and the staminate flower on the node 2–3 nodes behind it open on the same day. Pollination is effected by insects, mostly bees. Within 24 hours after pollination the pedicel starts to elongate and bends downward with the swelling ovary. The fruits are ready for harvesting 30–50 days after pollination, depending on climate and cultivar differences in fruit size and general earliness.

Other botanical information *C. lanatus* is a very variable species of old cultivation in the warmer parts of the world. Although no strict separation lines can be drawn, the species is sometimes subdivided into 3 subspecies:

- ssp. *lanatus* with var. *lanatus* for the 'tsamma' watermelon of South Africa and Namibia, important as water source for humans and animals in the semi-arid regions of the Kalahari and perhaps the ancestral form of the cultivated watermelon, and var. *citroides* (Bailey) Mansfeld for the fodder melon of South Africa, also cultivated in the United States and the Commonwealth of Independent States;
- ssp. *mucosospermus* Fursa, the 'egusi' watermelon of West Africa, especially important for its large, protein-rich seeds;
- ssp. *vulgaris* (Schrader) Fursa, with var. *cordophanus* (Ter-Avan.) Fursa for forms in East Africa important as water source in dry regions and var. *vulgaris* for the most important cultivated watermelon from all over the world. Three ecological-geographical groups are distinguished within var. *vulgaris*: (1) the Russian group; (2) the Eastern group; and (3) the Asiatic group.

'Charleston Gray', 'Crimson Sweet' and 'Sugar Baby' are well-known cultivars in South-East Asia, but there are several hundreds of open-pollinated and F_1 hybrid cultivars available to watermelon growers in the world. The following main types can be distinguished, using the name of a representative cultivar as type indicator:

– Fruits with sweet juicy flesh, containing seeds:
(1) 'Charleston Gray': fruit oblongoid to cylindrical, 6–15 kg, rind light green with small veins, flesh pink-red;
(2) 'Peacock': fruit oblongoid, 6–10 kg, rind dark green with thin, lighter stripes, flesh red;
(3) 'Flower Mountain': fruit oblongoid, 10–15 kg, rind light to medium green with mottled dark green stripes, flesh red;
(4) 'Crimson Sweet': fruit ovoid to globular, 1.5–10 kg, rind light green with mottled dark green stripes, flesh red or yellow;
(5) 'Sugar Baby': fruit globular, 3–8 kg, rind dark green, flesh red;
(6) 'Golden Crown': fruit globular to ovoid, 2–3 kg, rind yellow with narrow, light green stripes, flesh red;
(7) 'Icebox': general indication for all small-sized globular watermelons, 1.5–3 kg, rind green or yellow, flesh red or yellow.

– Fruits with sweet juicy flesh, without seeds:
always F_1 hybrids (triploids by crosses between tetraploid femaleand diploid male parent lines): fruit generally ovoid to globular, 1.5–8 kg; rind dark green, green with dark stripes or green with dark green veins; flesh mostly red, sometimes yellow.

– Seedy watermelon:
grown for the edible seed: fruits with many, rather large, red or black seeds; rind often dark green; flesh spongy white.

Ecology Watermelons are daylength neutral. A warm (day temperatures 25–30°C, night temperatures > 18°C), sunny and relatively dry climate is required for rapid growth and fruiting. Excessive rainfall and high humidity give excessive vegetative growth, affect flowering, induce leaf diseases and fruit rot. Market garden production is usually concentrated in the dry season, with furrow or drip irrigation. Soils should be well-drained, fertile loamy sands with high organic matter content and pH 6–7. At lower pH values, soilborne diseases (*Fusarium*) may become a serious problem.

Propagation and planting There is no seed dormancy, but germination can be accelerated by pre-soaking for 24 hours in water after scarifying the seed at one end, especially for cultivars which have a hard seed-coat. Watermelons are seeded directly (2–3 seeds, sown 2–4 cm deep on mounds or ridges) or transplanted after raising seedlings in 9 cm diameter pots of polythene, paper or banana leaves. In Japan, China and Taiwan, watermelon is sometimes grafted at the cotyledon stage on a *Fusarium*-resistant rootstock. This can be 'Citron', a bitter-tasting *C. lanatus,* bottlegourd (*Lagenaria siceraria* (Molina) Standley) or pumpkin (*Cucurbita maxima* Duchesne ex Lamk or *C. moschata* (Duchesne ex Lamk) Duchesne ex Poiret). Seedlings or grafted plants are transplanted to the field when they have 3–4 true leaves, some 5 weeks after sowing.
Planting distances are 0.9–1.2 m × 1.2–1.8 m giving a density of 5000–9000 plants/ha. Seed rates per ha are 1–2 kg for direct-seeded and 0.25–0.3 kg for transplanted watermelon.

Husbandry Growing watermelon directly after paddy rice is an effective way of avoiding soilborne diseases, in particular *Fusarium.* Minimum tillage is recommended to preserve residual moisture, but planting holes are dug to which NPK fertilizer and organic manure are added. Upland soils are ploughed and harrowed, organic manure (25–30 t/ha) is added to the planting beds and a basal application of 200–250 kg/ha NPK fertilizer. This is followed by applications of fertilizers as two side dressings or regularly as a liquid nutrient solution, type and rates according to local requirements.
Irrigation under upland conditions should be fre-

quent throughout the growing season, as the demand for water is high and the root system is rather shallow. Mulching with polythene sheets (black, transparent or silver-painted), rice straw and rice hulls is common practice to conserve moisture, raise or lower soil temperatures, to suppress weeds, and to prevent direct contact of the fruits with the soil. In the absence of mulch, frequent weeding will be necessary until the vines have covered the beds.

Vines are trained to prevent excessively dense vegetative growth and usually only two fruits per plant are left to mature, or 4–6 in small-fruited cultivars. Watermelon requires abundant insect pollinators to ensure sufficient fruit set and two beehives per ha are recommended to ensure maximum yield.

Diseases and pests There are a number of important diseases. *Fusarium* wilt (*Fusarium oxysporum* f.sp. *niveum*) with three races 0, 1 and 2, can be prevented by wide crop rotation (preferably 1 : 8 years), planting after paddy rice, ensuring good drainage, grafting on resistant rootstocks or using tolerant/resistant cultivars. Anthracnose (*Glomerella cingulata* var. *orbiculare,* formerly *Colletotrichum lagenarium*) can be controlled by copper and organic fungicides, but cultivars resistant to some races are available. Gummy stem blight (*Dydimella bryoniae,* formerly *Mycosphaerella citrullina*) is also controllable with fungicides, and sources of resistance in wild *Citrullus* accessions have been identified. Powdery mildew (*Erysiphe cichoracearum*) occurs but more important in hot and humid climates is downy mildew (*Pseudoperonospora cubensis*). Bacterial rind necrosis (*Erwinia carnegieana*) may be serious but varietal differences in susceptibility exist. Watermelon blotch is a new bacterial disease (*Acidovorax avenae* spp. *citrulli*), reported in China and the United States since 1989. Watermelon mosaic virus (WMV-2), papaya ring spot virus (PRSV-W) and zucchini yellow mosaic virus (ZYMV) are all transmitted by aphids such as *Aphis gossipii.*

Common insect pests are thrips (*Thrips* spp.), mites (*Tetranychus* spp.), aphids (*Aphis gossipii*), fruit fly (*Dacus ciliatus*), cucumber beetles (*Diabrotica* spp.), red pumpkin beetle (*Aulacophora* sp.) and *Epilachna* beetles. There are many types of insecticides to control the various insect pests, but indiscriminate spraying usually aggravates the situation by destroying useful parasitic insects. Polythene mulch, especially when coated with reflective aluminium paint, repels thrips and aphids.

Root knot nematodes (*Meloidogyne* spp.), particularly serious on sandy soils, can be prevented by crop rotation, destruction of susceptible weed hosts, soil fumigation (expensive and environmentally hazardous) and grafting on resistant rootstocks.

Harvesting The first fruits are ready for harvesting 65–90 days after transplanting to the field for most watermelon cultivars under tropical conditions. Indications of maturity are: the fruit gives a muffled sound when tapped, the light spot where the fruit rests on the ground has turned yellow, the fruit skin increases in lustre and loses trichomes, the tendrils directly opposite the fruit stalk are yellow and shrivelled. Watermelons do not ripen further after harvest. The fruit is cut from the vine with about 5 cm of stalk. Fruits harvested in the afternoon are less turgid and therefore less likely to crack during handling and transport.

Yield Averaging worldwide about 15 t/ha, but varying from 5–60 t/ha, depending on cultivar and cultural practices. Seed yields are 150–400 kg/ha.

Handling after harvest Watermelon fruits are rather fragile and susceptible to breakage and bruising. They should therefore be handled and shipped carefully. Fruits can be stored for more than 2 weeks at 10–15°C and 85% relative humidity.

Genetic resources Germplasm collections of watermelon are maintained at universities, horticultural institutes and gene banks in several countries, e.g. India, Japan, China, Taiwan (AVRDC), United States, Commonwealth of Independent States, Hungary, Bulgaria, Turkey, Iraq, Libya, Italy, South Africa. In the Philippines, about 60 accessions are maintained by the National Plant Genetic Resources Laboratory, Institute of Plant Breeding, Los Baños. There is a need to complement existing collections with additional germplasm of *C. lanatus* and related *Citrullus* species from the primary (central to southern Africa) and secondary (India, CIS, China) centres of genetic diversity.

Apart from the annual *C. lanatus*, which has bitter-fruited wild types from southern Africa as likely ancestors, three related African species form a valuable pool of germplasm for watermelon breeding because they all can be intercrossed successfully:

- *C. colocynthis* (L.) Schrader (synonym: *Colocynthis vulgaris* Schrader), the colocynth, a perennial species from northern Africa to Afghanistan and Pakistan, with small fruits and

white, bitter flesh;
- *Anthosicyos naudinianus* (Sonder) C. Jeffrey (synonym: *Citrullus naudinianus* (Sonder) J.D. Hooker), a perennial species from south-western Africa, with thin-walled but spiny fruits, containing juicy flesh;
- *C. ecirrhosus* Cogn. (synonym: *Colocynthis ecirrhosus* (Cogn.) Chakrav.), a perennial species from south-western Africa, without tendrils and with very bitter fruits, adapted to the extreme climatic conditions of the Namib desert.

Breeding Whereas in the United States all major watermelon breeding programmes until recently concentrated on developing open-pollinated cultivars with large oblong fruits, Japanese breeders started producing F_1 hybrid cultivars back in the 1930s and focused more on round-shaped, medium to small fruits. Also in Japan the technique of producing seedless (triploid) watermelon hybrids was developed in the early 1940s. However, seedless hybrids are difficult and expensive to produce (only 40–80 seeds per fruit), seeds are often difficult to germinate and fruits mature some 10 days later than comparable diploid cultivars. Seedless watermelon production therefore became more popular in Taiwan and other countries outside Japan with warmer climates and lower costs of seed production. In Asia, major watermelon breeding programmes are presently carried out by governmental institutes, universities and private breeders in India, Japan, mainland China and Taiwan.
Main breeding objectives include: compact plant types (short internodes), earliness (low number of days to first fruit set and from fruit set to maturity), fruit size and shape (small and round), fruit quality (thin but strong rind, high sugar content, finely grained flesh with small seeds, no hollow heart), disease and pest resistance (first priority *Fusarium*, anthracnose and virus), and improved seed production of seedless types. The most popular cultivars grown in South-East Asia originate from Taiwanese seed companies.

Prospects The demand for watermelon, especially the smaller, ovoid to globular types, is rapidly increasing in many South-East Asian countries. Sources of resistance to the most important diseases (and pests) have been identified in wild accessions of *C. lanatus* and in related species. The longer term prospects of reducing dependence on pesticides when producing watermelon are therefore good. Male-sterile mutants have been found, giving prospects of seed production of F_1 hybrids by bee pollination instead of hand pollination. New techniques from molecular biology (genetic transformation and DNA markers) can further increase breeding efficiency in watermelon, e.g. in resistance to virus diseases.

Literature |1| Deanon Jr, J.R. & Villegas, G.G. 1984. Watermelon. In: Bondad, N.D. (Editor): Philippine science encyclopedia. National Research Council of the Philippines, Manila, the Philippines. |2| Fursa, T.B., 1981. Intraspecific classification of water-melon under cultivation. Kulturpflanze 29: 297–300. |3| Mohr, H.C., 1986. Watermelon breeding. In: Bassett, M.J. (Editor): Breeding vegetable crops. Avi Publishing Company, Westport, Connecticut, United States. pp. 37–66. |4| Shinohara, S. (Editor), 1984. Vegetable seed production technology of Japan. Shinohara's Authorized Agricultural Consulting Engineer Office, Tokyo, Japan. Vol. 1. pp. 318–339. |5| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 150–152. |6| Whitaker, T.W. & Davis, G.N., 1962. Cucurbits: botany, cultivation and utilization. Leonard Hill, London, United Kingdom. 250 pp. |7| Yamaguchi, M., 1983. World vegetables: principles, production and nutritive values. Avi Publishing Company, Westport, Connecticut, United States. pp. 327–330.

M.M. Paje & H.A.M. van der Vossen

Cleome gynandra L.

Sp. pl.: 671 (1753).
CAPPARACEAE
$2n = 36$

Synonyms *Cleome pentaphylla* L. (1763), *Gynandropsis pentaphylla* (L.) DC. (1824), *G. gynandra* (L.) Briq. (1914).

Vernacular names Bastard mustard, cat's whiskers, spider flower (En). Indonesia: maman(g), enceng-enceng (Java), bhubhuwan (Madura). Malaysia: mamang. Philippines: apoy-apoyan (Tagalog), manabo (Ilocano), balaya (Bisaya). Cambodia: momiĕnh. Laos: siènz. Thailand: phak sian, phak sian khao (central), phak som sian (northern). Vietnam: m[af]n m[af]n tr[aws]ng.

Origin and geographic distribution *Cleome gynandra* is considered native to Asia, but is widely distributed as a weed in the Old World tropics and has also been introduced into tropical America. It has been brought into cultivation in Asia and Africa, but is only of local importance.

Uses The very bitter leaves are eaten as a vegetable. Cooking and fermentation both reduce the bitterness. Often the leaves are salted and used as a pickle. In East and West Africa it is used as a pot herb and as a flavouring for sauces. Both leaves and seeds are used medicinally as rubefacient, vesicant, and for many other ailments, externally as well as internally. The seeds are used as a substitute for mustard, hence the English name, and they yield a good oil.

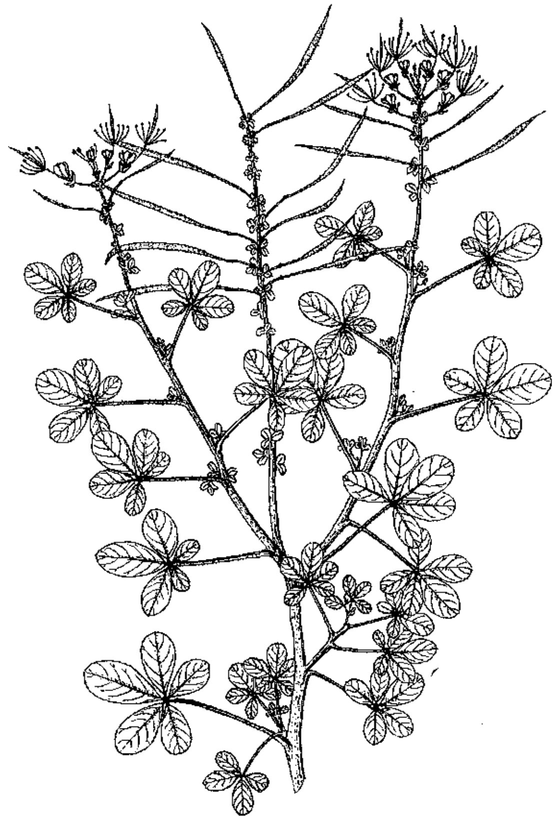
Extracts of the seeds have proven to be reasonably effective as a natural insecticide in India. In temperate climates, *C. gynandra* is grown as a summer ornamental.

Production and international trade *C. gynandra* is a common market vegetable in Malaysia and Thailand, where it is sold fresh or in brine.

Properties Information on the nutritive composition is scarce. The leaves (West African sample) contain per 100 g edible portion: water 90 g, protein 3.9 g, fat 0.3 g, carbohydrates 3.6 g, fibre 0.8 g, ash 1.4 g. East African leaf samples have been reported to contain per 100 g edible portion: Ca 250 mg, Fe 10 mg, carotene > 7 mg, vitamin C 131 mg. The energy value is 137 kJ/100 g.

The constituents of the seeds are cleomin, an unsaturated lactone, tannins, reducing sugars and an acrid volatile oil, comparable with mustard oil. The volatile oil is also present in the leaves, and is responsible for the odour and flavour of the vegetable. The main constituents of the volatile oil seem to be ß-sitosterol (87%), campesterol (9%) and cholesterol (3%).

Botany An erect annual herb, up to 1 m tall. Stem usually widely branched, densely covered with glandular hairs. Leaves alternate, normally palmately compound, with 5 leaflets, lowest and upper leaves with 3 leaflets, smaller towards and in the inflorescence; petiole 2–10 cm long; petiolules 1–3 mm; leaflets obovate to lanceolate, 2–7.5 cm × 1–3.5 cm; narrowly cuneate at base, obtuse to short-acuminate at apex, ciliate to denticulate, thinly herbaceous. Inflorescence an elongated terminal leafy few- to many-flowered raceme; flowers white or tinged with purple; pedicel 1.5–2.5 cm long; sepals 4, free, ovate to lanceolate, 2.5–6 mm × 0.5–2 mm; petals 4, elliptical to obovate, 7–15 mm × 1.5–4 mm, including a 1.5–5 mm long slender claw; androgynophore 9–16 mm; stamens 6, anthers purple; ovary on a slender stalk (gynophore), which is 1–2 mm long in flower, accrescent to 10 mm in fruit. Fruit a long, narrow, cylindrical capsule, 2–11 cm × 3–6 mm, on a 1–3 cm long pedicel, with a 1–4 mm long beak, splitting from below into 2 valves. Seeds numerous, depressed-globular, about 1 mm in diameter, dark brown, with a shallow and narrow cleft, irregularly ribbed.



Cleome gynandra L. – flowering and fruiting shoot.

For the distinction between *C. gynandra* and other *Cleome* L. species occurring in South-East Asia, the most important diagnostic features of *C. gynandra* are the long androgynophore, the short gynophore, and the basic white colour of the petals. *C. gynandra* is a night-flowering plant.

Ecology *C. gynandra* is a common weed along roadsides, on dikes of rice fields, and sandy borders of rivers. It occurs from the lowlands up to 500 m and flowers and fruits year-round. It grows best in full sunlight and rich soils where there is plenty of room to spread. *C. gynandra* has a C4-cycle photosynthetic pathway, which means a high photosynthesis at high temperature and radiation. It is rather drought resistant and sensitive to waterlogging.

Agronomy *C. gynandra* is propagated by seed.

Seeds are sown by broadcasting on a nursery bed followed by transplanting, or are direct-seeded in rows followed by thinning. The planting distance should be 20–30 cm × 20–30 cm. Leaves can be harvested from the second month onwards. It flowers and fruits abundantly and the yield of green vegetable is generally small. The leaves can be preserved by drying, a very common practice in Africa.

Prospects *C. gynandra* is more popular in Africa than in Asia probably owing to the general preference of Africans for bitter foodstuffs. At present, the main attention seems to be given to its chemical constituents, in view of medicinal or pesticidal applications. As a vegetable, however, it may have the best potential for somewhat drier climates, although more productive types need to be selected.

Literature |1| Busson, F., 1965. Plantes alimentaires de l'Ouest africain [Food plants of West Africa]. Ministère de la Coopération, Paris, France. pp. 200–203. |2| Imbamba, S.K. & Tieszen, L.L., 1977. Influence of light and temperature on photosynthesis and transpiration in some 3 carbon and 4 carbon vegetable plants from Kenya. Physiologia Plantarum 39(4): 311–316. |3| Jacobs, M., 1960. Cleome. In: van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 6. Wolters-Noordhoff Publishing, Groningen, the Netherlands. pp. 99–105. |4| Perry, L.M., 1980. Medicinal plants of East and Southeast Asia. Massachusetts Institute of Technology, Cambridge, Massachusetts, United States.

K. Chayamarit

Coccinia grandis (L.) Voigt

Hort. suburb. Calc.: 59 (1854).
CUCURBITACEAE
$2n = 24$

Synonyms *Bryonia grandis* L. (1767), *Coccinia indica* Wight & Arnott (1834), *C. cordifolia* (auct. non L.) Cogn. (1881).

Vernacular names Ivy gourd, small gourd, scarlet gourd (En). Indonesia: papasan, kemarongan (Java), bolu teke (Java). Malaysia: pepasan, papasan. Cambodia: slök baahs. Laos: tam ling, tam nin. Thailand: phaktamlung (general), phakkhaep (northern). Vietnam: hoa b[as]t, rau b[as]t.

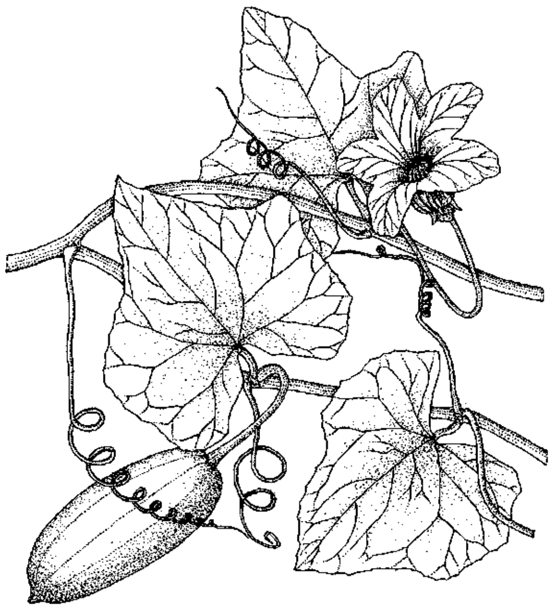
Origin and geographic distribution The genus *Coccinia* Wight & Arnott with about 30 species is confined to tropical Africa, with the exception of *C. grandis,* which occurs wild from Africa to the Indo-Malaysian region. It is cultivated mainly in India, Thailand, Malaysia and Indonesia.

Uses Young shoots and leaves of ivy gourd are consumed as fried, blanched or boiled vegetable for the rice table, noodles or soups. It is a very popular green in Thailand. The young fruits are used in soups and curries. The ripe fruits of sweet cultivars can be eaten raw and they are sometimes comfited. The fruits of wild forms are often very bitter. The flesh can be processed into fermented or dehydrated chips which can be stored over a long period. Ivy gourd has many applications in indigenous medicine (poultice, antipyretics), but few clinical data on the effectiveness are available. It may have some potential value in the treatment of diabetes.

Production and international trade Leaves and fruits of ivy gourd are regularly offered for sale on local markets, but it is not traded to a great extent. No production statistics are available.

Properties Per 100 g edible portion, the fruits contain: water 94 g, protein 1–2 g, fat 0.1 g, carbohydrates 3.1 g, traces of vitamin A, vitamin B_1 0.07 mg, vitamin B_2 0.08 mg, niacin 0.7 mg, vitamin C 15 mg, Ca 40 mg, Fe 1.4 mg, P 30 mg. The energy value is 72–90 kJ/100 g.
The leaves are a good source of protein (3.3–4.9 g), minerals and vitamins, in particular vitamin A (8000–18000 IU).

Description A perennial, dioecious, climbing or trailing herb up to 20 m long with tuberous roots. Stem green and longitudinally ribbed when young, becoming white-spotted when older and eventually woody and subterete; tendrils simple, usually one per node, in stipular position. Leaves simple, alternate, with petiole of 1–5 cm; leaf-blade broadly ovate to subpentagonal or orbicular in outline, 3–12 cm × 3–15 cm, shallowly to deeply palmately 3–5-lobed, cordate at base, margin entire or sinuate and often with distinct reddish glandular teeth, glabrous, punctate. Male flowers axillary, solitary or paired, rarely 3–4 in a short raceme; pedicel 0.7–7 cm long; receptacle tubular, 3–7 mm long; sepals 5, linear, up to 6 mm long; corolla campanulate, yellow-orange, green veined, 5-lobed, lobes up to 2 cm × 1.5 cm; staminal column 6 mm long. Female flowers axillary, solitary; pedicel up to 2.5 cm long; receptacle, calyx and corolla as in male flowers; ovary cylindrical, up to 1.5 cm long, style 3 mm long, stigma 3-lobed, each lobe 2-lobed. Fruit baccate, ellipsoid or rarely



Coccinia grandis (L.) Voigt – flowering and fruiting shoot.

spherical, 3–7 cm × 1–3.5 cm, fleshy, green with white stripes when young, turning red at maturity; fruit stalk up to 4 cm long. Seed asymmetrically pyriform in outline, compressed, 6 mm × 3 mm × 1.5 mm, margin rather thick and grooved, testa fibrillose.

Other botanical information The 12 chromosome pairs comprise a distinct heteromorphic pair of sex chromosomes in male plants (22 + XY), whereas female plants are homogametic (22 + XX).
The wild and cultivated forms are sometimes described as distinct botanical varieties, i.e. var. *wightiana* (Roemer) Grebenscikov for the wild forms and var. *grandis* for the cultivated forms. It is preferable, however, to classify the cultivated forms directly as cultivars below species level.

Ecology Ivy gourd occurs wild in grassland, brushwood, on roadsides, in hedges and light forests from the plains up to 1500 m altitude. Little is known about optimum ecological conditions, and their influence on growth and development. Ivy gourd seems to require well-distributed rainfall and fairly high humidity. Soils should be well-drained as it is intolerant to waterlogging.

Agronomy Ivy gourd is the only cucurbit usually propagated by stem cuttings, 10–15 cm in length and 0.5 cm in diameter, which are planted in well-manured planting holes, spaced 1.5–2 m apart. Propagation by seed is also possible but little practised because of the dioecious nature of ivy gourd (50% non-productive male plants). A ratio of 1 : 10 male to female plants is considered adequate for pollination purposes. Ivy gourd is usually grown with a trellis support, or trained over fences or roofs in home gardens. The cultural practices and pest control of ivy gourd and bitter gourd (*Momordica charantia* L.) are very similar.
Foliar diseases include anthracnose (*Colletotrichum* sp.), powdery mildew (*Erysiphe cichoracearum*) and downy mildew (*Pseudoperonospora cubensis*), but there is little information on the extent of damage. Pests of ivy gourd are aphids (*Aphis* spp.), red pumpkin beetle (*Aulacophora* sp.) and fruit flies (*Dacus* spp.).
Individual plant yields are in the order of 10 kg of immature fruits per year. However, ivy gourd is often primarily grown as a leafy vegetable. Young shoots wilt rapidly and should be marketed and consumed soon after harvest.

Genetic resources and breeding *C. grandis* is only sparsely represented in the germplasm collections of some Indian research institutes. The selection work in India has resulted in several attractive sweet cultivars.

Prospects Relatively little information from South-East Asia is available on this naturally occurring crop. More research is needed to assess its potential as a vegetable or as a medicinal plant.

Literature |1| Bates, D.M., Robinson, R.W. & Jeffrey, C. (Editors), 1990. Biology and utilization of the Cucurbitaceae. Comstock, Cornell University Press, Syracuse, New York, United States. p. 21. |2| Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. p. 318. |3| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 188–190. |4| Perry, L.M., 1980. Medicinal plants of East and Southeast Asia. Massachusetts Institute of Technology, Cambridge, Massachusetts, United States. p. 114. |5| Ramachandran, K. & Subramaniam, B., 1983. Scarlet gourd, Coccinia grandis, little-known tropical drug plant. Economic Botany 37(4): 380–383. |6| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 152–154.

T. Boonkerd, B. Na Songkhla & W. Thephuttee

Cosmos caudatus Kunth

Nov. gen. sp. 4: 240 (1820).
COMPOSITAE
$2n = 48$

Synonyms *C. bipinnatus* Ridley (1923), non Cavanilles (1791).

Vernacular names Cosmos (En). Indonesia: kenikir (Java), randa midang (West Java). Malaysia: ulam raja, pelampong. Philippines: cosmos (Tagalog), turay-turay (Bisaya), onwad (Ifugao). Thailand: daoruang-phama (Bangkok), khamhae (northern).

Origin and geographic distribution Cosmos is indigenous to tropical America. It was introduced by the Spaniards into the Philippines, possibly because it was used by them as a vegetable at sea. Now it is pantropical, including South-East Asia, where it is cultivated but also occurs in a naturalized state.

Uses The leaves and young tops of cosmos are eaten as a vegetable in Indonesia and Malaysia, usually raw but also cooked and mixed with coconut sauce and chillies. The leaves have a very strong taste and smell of turpentine. Besides being used as a vegetable, cosmos is also grown for ornamental purposes; it occurs in many home gardens in Indonesia. In Malaysia it is used as a traditional medicine to purify the blood and to strengthen the bones. In the Philippines (Luzon) the leaves are reportedly used, mixed with rice, to prepare yeast. In early days cosmos was proposed as an auxiliary plant in agriculture, in particular to improve the soil structure and to suppress alang-alang (*Imperata cylindrica* (L.) Raeuschel).

Production and international trade Cosmos is mainly cultivated for home consumption and marketed locally on a small scale. No production statistics are available.

Properties Per 100 g edible portion, cosmos contains: water 93 g, protein 3 g, fat 0.4 g, carbohydrates 0.4 g, fibre 1.6 g, ash 1.6 g. Contents of Ca (270 mg) and vitamin A (0.9 mg) are high. The energy value is low, being 70 kJ/100 g edible leaves. The leaves also contain an essential oil.

Botany Annual to short-lived perennial herb, erect, in the upper half much branched, aromatic, up to 3 m tall. Stem longitudinally striate, green, often tinged with purple. Leaves opposite, 2–4 pinnate or pinnatipartite, triangular-ovate in outline, 2.5–20 cm × 1.5–20 cm, above dark green, subglabrous, below light green with minute hairs; petiole up to 5 cm long; ultimate leaf segments oblong-lanceolate, 0.5–5 cm × 1–8 mm. Inflorescence a head, terminal (with other heads forming a lax panicle) or axillary, solitary, in the axils of the higher leaves; peduncle 5–30 cm long; involucral bracts 8, linear-lanceolate, 1.5–2 cm long and reflexed in fruit; ray flowers 8, sterile, ligules linear-lanceolate, 1–1.5 cm × 0.5 cm, mostly violet or reddish, seldom yellow or white; tubular flowers bisexual, numerous, yellowish-green, 0.7–1 cm long. Fruit an achene, linear-fusiform, 4-angular, 1–3 cm long, black, ending in a beak with 2–3 short unequal awns.

Cosmos caudatus Kunth – flowering and fruiting shoot.

C. caudatus can be easily confused with *C. sulphureus* Cav. because they look similar vegetatively and have some vernacular names in common (randa midang). They can be distinguished by the achenes: those of *C. caudatus* have conspicuous awns which are absent in *C. sulphureus*. The latter is more important as an ornamental, much less as a leafy vegetable.

Ecology When not cultivated, cosmos often occurs as a weed in the neighbourhood of human habitations, e.g. in fields and waste places, from the lowlands up to 1600 m altitude. It likes sunny places with a not too humid atmosphere and a fertile and pervious soil.

Agronomy Propagation is by seed. Sowing is done directly in the field or first in a nursery. The seedlings are transplanted to the field when they are three weeks old. Planting distances of 25–30 cm × 25–30 cm are recommended. On poor soils fertilizing with organic manure (10 t/ha) and urea (200 kg/ha) will increase the yield and improve leaf quality, as will good drainage in wet conditions and watering during dry periods. After 6 weeks the first leaves can be harvested and subsequent harvests can be every 3 weeks. Regular harvesting will stimulate production and delay flowering, and can continue until the plant is 2–3 years old. In humid conditions cosmos is often attacked by fungi (e.g. *Sclerotium rolfsii*). Cosmos wilts easily and therefore should be marketed soon after harvesting.

Genetic resources and breeding Selection, if any, has only been done by growers. A comparison of planting materials from home gardens and market gardens would provide some insight into the variation present.

Prospects In some parts of South-East Asia, particularly in Indonesia and Malaysia, cosmos is a popular vegetable. In West Java it is becoming rather common in the assortment of fresh vegetables in supermarkets, which might give an impetus to new developments in this crop.

Literature |1| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische groenten', 1931). Asher and Co., Amsterdam, the Netherlands. pp. 125–127. |2| Soetomo Soedirdjoatmodjo, M.D., 1986. Bertanam sayur daun [Growing leafy vegetables]. Badan Penerbit Karya Bani, Jakarta, Indonesia. pp. 54–59.

M.H. van den Bergh

Cucumis melo L.

Sp. pl.: 1011 (1753).
CUCURBITACEAE
$2n = 24$

Synonyms *C. melo* L. var. *agrestis* Naudin (1859), *C. melo* L. var. *cultus* Kurz (1877).

Vernacular names Melon, musk melon, cantaloupe (En). Melon (Fr). Indonesia: blewah, semangka londo. Malaysia: bluwak. Papua New Guinea: melon. Philippines: milon (Tagalog), itimon (Ilocano), atimon (Bisaya). Cambodia: trâsâk sröö'w. Laos: tèèng laay, tèèng suk. Thailand: taeng-thai (central), taeng-lai (central). Vietnam: d[uw]a b[owr], d[uw]a h[oof]ng.

Origin and geographic distribution Melon probably originated in eastern and north-eastern Africa where wild forms still occur. It reached the Mediterranean region some 2000 years ago and was subsequently introduced into Asia. Important secondary centres of genetic diversity developed in Spain, Iran, Uzbekistan, Afghanistan, India, China and Japan. Melon is now distributed worldwide.

Uses Mature fruits of most melon cultivars are consumed fresh for the juicy and sweet-tasting flesh. The pulp can also be mixed with water and sugar, or sometimes with milk, and served as a refreshing drink. Immature fruits of certain types are also used as a fresh, cooked or pickled vegetable. The seeds are eaten after roasting; they contain an edible oil.

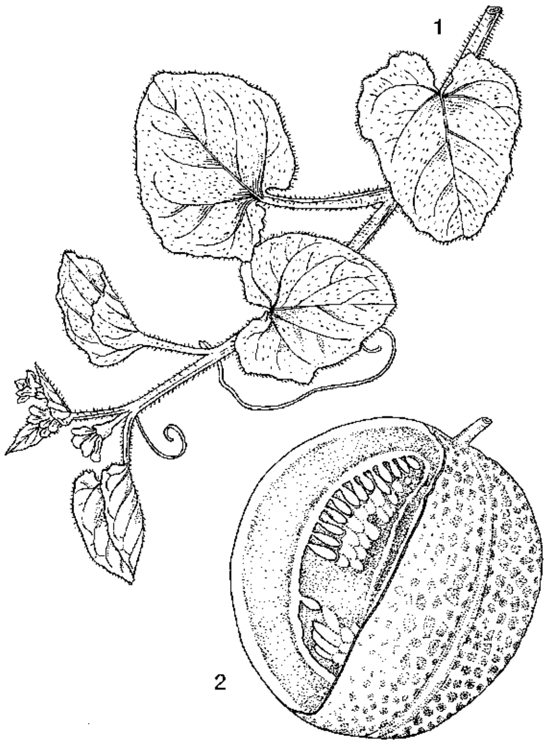
Production and international trade Annual world production is about 9 million t (700 000 ha). Major melon-producing countries are China and Turkey (150 000 ha each), India (100 000 ha), Spain (70 000 ha), United States (42 000 ha), Romania (30 000 ha), Japan (18 000 ha), Italy (17 000 ha), France (16 000 ha), Taiwan (9000 ha), Australia (3000 ha).

Melon is a typical fruit vegetable of the dry and warm subtropical and temperate climates. In tropical Asia it is more a luxury crop for urban markets, grown in the drier lowlands and highlands. Statistics on production are incomplete for these countries, but it is generally a minor crop, except in the Philippines (ca. 2000 ha).

Each country has its own specific local melon cultivars (landraces) and most of the crop is sold to local markets. Production for export markets has developed in Mediterranean countries, United States, Australia, Taiwan and Japan, using F_1 hybrid cultivars of the musk melon type in particular, with long shelf-life characteristics.

Properties Melon is generally low in protein and rich in sugars, vitamins and minerals. The edible portion (45–80% of the mature fruit) contains per 100 g: water 87–92 g, protein 0.6–1.2 g, fat 0.1–0.2 g, carbohydrates (mainly sugars) 6–15 g, vitamin A 500–4200 IU, vitamin B_1 0.06 mg, vitamin B_2 0.02 mg, niacin 0.4–0.9 mg, vitamin C 6–60 mg, K 130–330 mg, Ca 5–18 mg, Fe 0.2–0.6 mg, Mg 8–17 mg, P 7–57 mg. The energy value is 75–220 kJ/100 g. The edible seed kernel contains approximately 46% of a yellow oil and 36% protein. The weight of 1000 seeds is (8–)25–35 g.

Description A variable, climbing, creeping or



Cucumis melo L. – 1, flowering shoot; 2, fruit (rind and flesh partly removed).

trailing, herbaceous, hairy, annual, andromonoecious or monoecious vine. Root system large, mostly distributed in the top 30–40 cm of the soil, a few roots descending to 1 m depth. Stem ridged or striate, 1.5–3 m long. Leaves simple, alternate; leafblade orbicular or ovate to reniform, 3–15(–20) cm in diameter, angular or shallowly palmately 5–7-lobed, base cordate, margins shallowly sinuate-toothed, surfaces hairy; petiole 4–10 cm long; tendrils unbranched. Flowers axillary, either staminate and clustered (2–4 together), or pistillate or hermaphrodite and solitary, 1.2–3.0 cm in diameter, yellow, on short, 0.5–3 cm long, stout pedicels; calyx 5-lobed, 6–8 mm long; corolla deeply 5-partite, 2 cm long, lobes suborbicular; stamens 3, of which 2 double 2-thecous and 1 single 1-thecous, free, connectives of anthers prolonged; pistil with inferior ovary, 3–5 placentas, united style and 3–5 stigmas; nectaries at base of style and stamens. Fruit a pepo, very variable in size and shape, globular, ovoid or oblongoid, smooth or furrowed; rind smooth to rough and reticulate, white, green, yellowish-green, yellow, yellowish-brown, speckled yellow or orange with green or yellow background; flesh yellow, pink, orange, green or white; fruit weight is 0.4–2.2 kg. Seeds numerous (300–500 per fruit), compressed elliptical, 5–12 mm × 2–7 mm × 1–1.5 mm, whitish or buff, smooth.

Growth and development Melon seed will remain viable for at least 5 years when stored dry (moisture content 6%) at temperatures below 18°C. Germination is epigeal and seedlings appear within 4–8 days after sowing. The first true leaf appears 5–6 days after unfolding of the cotyledons. The first 2–4 axillary buds on the main stem produce vigorous primary stems which check the growth of the main stem. The first clusters of male flowers appear on the 5th–12th node of primary branches, while hermaphrodite or female flowers appear on secondary laterals, formed from the 14th node of primary stems onwards. Flowers are open for one day only and pollination is effected by insects, mostly bees. The fruit is a heavy sink for assimilates and minerals and usually only 3–6 out of 30–100 female/hermaphrodite flowers per plant will develop into mature fruits. The fruit development curve is sigmoid with maximum growth (for most musk melons) at 10–40 days after flowering; maturation with little further expansion occurs during the last 10 days when sugars accumulate in the fruit flesh and the net tissue on the fruit surface develops. Upon ripening, the fruit softens and fruity aromatic essences are exuded by the fruit. Fruits mature 90–120 days after sowing.

Other botanical information Melon is a highly polymorphic species with many different cultivars developed over time to meet local taste and preference. For modern market gardening the following main types or cultivar groups can be distinguished.

Sweet melon types used as fruit:

- Musk Melon (var. *reticulatus* Naudin): fruit globular (1–1.8 kg); rind strongly reticulate, sometimes furrowed, yellowish-green with orange flesh (Italo-American) or rind finely reticulate to smooth, yellowish-green with light green flesh (Japanese, Mediterranean-Galia); high sugar content (10–15%) and aromatic; good for shipping;
- Cantaloupe Melon (var. *cantalupensis* Naudin; convar. *melo*): fruit globular to slightly ovoid (1.2–1.8 kg); rind smooth or reticulate, ribbed, greyish-green with orange flesh (French 'Charantais'); high sugar content and very rich flavour; limited storability; mainly grown in western Europe and the United States;
- Winter Melon (var. *inodorus* Naudin; convar. *zard* (Pang.) Grebenscikov): fruit ovoid (1.5–2.5

kg); late maturing; rind smooth, often striped or splashed, grey, green or yellow in colour; flesh firm, white or light green (e.g. 'Casaba', 'Honeydew'); high sugar content but little flavour; good storage quality; mainly grown in Iran, Central Asia and Afghanistan, but also in Spain and Japan;

- Chinese Hami: fruit ovoid to oblong (1.5–2.0 kg); rind yellowish to light green, slightly reticulate; flesh crisp, light orange to pink; very sweet (14% sugar); good shelf life; adapted to cool climates;
- Oriental Sweet Melon: fruit small, globular to ovoid (0.4–0.6 kg); rind smooth, pale green to yellow with white, crisp flesh; very sweet but little flavour; adapted to hot and humid climates; seeds are small (1000-seed weight 8–10 g).

Non-sweet melon types used as vegetable:

- Snake Melon (var. *flexuosus* Naudin; convar. *flexuosus* (L.) Grebenscikov): fruit long, slender, with smooth rind; used immature as cucumber, mainly in Afghanistan, Iran and the Commonwealth of Independent States;
- Oriental Pickling Melon (var. *conomon* Makino; convar. *conomon* (Thunberg) Grebenscikov): fruit small, elongated like cucumber; mainly used in India, China, Japan and South-East Asia; in Indonesia the young green fruits ('ketimun krai') are consumed in the same way as cucumber, although they have a flat taste and little flavour; the mature fruits ('ketimun poan') are oval-cylindrical and have a typical rind, which is smooth, yellow with white longitudinal striping; they may become very big (weighing more than 5 kg) and are used for the preparation of candy or eaten with ice and sugar as a delicacy;
- Garden Melon (var. *chito* Naudin): fruit small, smooth, mottled; used for pickles and as ornamental, mainly in southern Europe and the United States;
- Pomegranate Melon (var. *dudaim* Naudin; convar. *dudaim* (L.) Grebenscikov): fruit small, globular, pubescent; mainly in south-western Asia, Transkaukasia and northern Africa; also used as ornamental and odoriferous fruit.

Imported F_1 hybrid cultivars are becoming popular and are replacing local materials. Popular cultivars in Indonesia are 'Jade Dew' and 'Honeydew' of the Winter Melon type, 'Sky Rocket' of the Musk Melon type, and 'Hales Best' of the Cantaloupe type.

Ecology Melon requires warm and dry weather with plenty of sunshine for growth and production. The optimum temperature range is 18–28°C, growth being severely retarded below 12°C. Plants are killed instantly by frost. Melon is grown from moderate elevations up to about 1000 m altitude; in Java between 300 and 800 m above sea-level. High humidity will reduce growth, adversely affect fruit quality and encourage leaf diseases. Melon grows best on deep, well-drained and thoroughly cultivated fertile loamy soils with pH 6–7. Melons are often grown with furrow or drip irrigation.

Propagation and planting Melon is usually direct-seeded: 2–3 seeds, sown 2–4 cm deep on mounds or ridges, later thinned to one plant. Spacing is 50–75 cm within and 150–200 cm between the rows, giving a density of 10 000–15 000 plants per ha. Alternatively, seedlings are raised in polythene pots or in soil blocks and transplanted carefully to the field when 4 weeks old, taking care not to damage the root system. Seed rates per ha are 1.5–2 kg for direct-seeded melon and 0.5 kg for the transplant method.

Husbandry Melon can be grown in normal upland conditions, provided that it is rotated with non-cucurbit crops to avoid soilborne diseases and nematodes, or in a paddy field immediately after harvesting the rice crop. The upland soil should be ploughed, harrowed and rotovated to attain a well-pulverized and well-levelled soil. The rice field requires minimum tillage to prevent loss of residual moisture and soil compaction. Irrigation under upland conditions should be frequent, since plants have a high demand for water until the fruits have reached maturity.

Fertilizer requirements depend on crop performance and nutrient status of the soil. Removal of nutrients in a harvest of 20 t/ha of fruits is: N 60–120 kg, P_2O_5 20–40 kg, K_2O 120–140 kg, CaO 100–140 kg and MgO 20–60 kg. Melon responds well to organic manures applied at 25–30 t/ha. A complete fertilizer should be applied before sowing/planting, followed by regular applications of liquid fertilizer during the growing season.

Mulching is one of the well-established practices in the production of melon. In subtropical areas, black, transparent or silver-painted polyethylene sheets are commonly used not only to control weeds but also to raise or lower the soil temperature. In the tropics, common mulching materials used are rice straw and rice hulls. In areas where mulching materials are not available, weeding is necessary until the plants start vining. Hand hoeing or pulling of large weeds is often practised.

Various methods of pruning primary and secondary stems are applied to regulate vegetative growth and fruit set (3–5 per plant).

Diseases and pests There are a number of important diseases. *Fusarium* wilt (*Fusarium oxysporum* f.sp. *melonis*) can be effectively prevented only by resistant cultivars (races 0, 1, 2 and 1–2). Powdery mildew (*Sphaerotheca fuliginea* and *Erysiphe cichoracearum*) can be controlled by fungicides, but modern F_1 hybrids have high tolerance of most races. Downy mildew (*Pseudoperonospora cubensis*) is important in hot and humid climates and can be controlled by fungicides; polygenically controlled resistance is available in certain Indian accessions. Gummy stem blight (*Dydimella bryoniae*, formerly *Mycosphaerella citrullina*) is also a disease in humid and hot conditions. Anthracnose (*Glomerella cingulata*, formerly *Colletotrichum lagenarium*) can be controlled by seed treatment, crop rotation and fungicides. Damping-off (*Pythium* sp. and *Rhizoctonia* sp.) has to be prevented by treating seed with fungicides (e.g. thiram). Bacterial soft rot (*Erwinia tracheiphila*) is controlled by removing affected plants and by eliminating the vector (the striped and spotted cucumber beetle) with insecticide sprays. Angular leaf-spot (*Pseudomonas syringae*) has been reported on melon in Indonesia. Cucumber mosaic virus (CMV), watermelon mosaic virus (WMV-2) and zucchini yellow mosaic virus (ZYMV), all three transmitted by aphids, in particular *Aphis gossipii*, affect melon; there are various sources of resistance to these three viruses and also to the vector *A. gossipii.* Other virus diseases in melon are papaya ring spot (PRSV, aphid transmitted), melon necrotic spot (MNSV, transmitted by the soil fungus *Olpidium* sp.) and curly top (transmitted by leafhoppers).

Pests in melon are thrips (*Thrips palmi* and *Frankiniella* spp.), spider mite (*Tetranychus urticae*), aphids (*Aphis gossipii*), melon fruit fly (*Dacus cucurbitae*), cucumber beetles (*Diabrotica* spp.), leaf folder (*Diaphania indica*), leaf feeder (*Aulacophora similis*) and the fly *Bactrocera cucurbitae,* which is especially active in the humid tropics and causes young fruits to drop by tunnelling in the pedicel. Farmers usually control these pests with insecticides. However, indiscrimate use of insecticides only aggravates the pest problems by destroying useful parasitic insects.

Root knot nematodes (*Meloidogyne* spp.) can be a serious problem when melons are grown without proper crop rotation; control by wide-spectrum soil fumigants can be effective, but it is expensive and hazardous to the environment.

Harvesting Cantaloupe and musk melon tend to separate from the pedicel at the base of the fruit at maturity due to the formation of an abscission layer. This is called 'full slip'. Harvesting occurs usually at the 'half slip' stage. Winter and Chinese Hami melons do not form an abscission layer and maturity is indicated by colour change, e.g. from green to yellow.

Yield Averaging 13 t/ha of fresh fruits, but ranging from 5–30 t/ha depending on cultivar and cultural practices. Seed yields are about 300–500 kg/ha for open-pollinated and 100–200 kg/ha for hybrid cultivars.

Handling after harvest Musk melons for storage should be predominantly green in colour (sugar content more than 10%) and cooled to 10–15°C immediately after harvesting to retard ripening. Storage for 10–15 days at 3–4°C (90% relative humidity) is possible, but lower temperatures can cause chilling injury. 'Honeydew', other winter melons and Chinese Hami melons can be stored at 10–15°C for longer periods, some cultivars up to 90 days. Heavily netted melons (e.g. 'American Western Shipper') are relatively resistant to handling and transport.

Genetic resources The genetic diversity within *C. melo* is fairly well preserved in germplasm collections of universities, horticultural institutes and gene banks in the United States (USDA, Georgia and New York), Spain (INIA), France (INRA), Italy (Bari), Egypt, Israel, India, Japan (NIAS), China, CIS (VIR) and other countries. These could be complemented by further collection of germplasm in the secondary centres of genetic diversity in Afghanistan, Pakistan, India and China. In the Philippines, 105 accessions are being maintained at the National Plant Genetic Resources Laboratory, Institute of Plant Breeding, Los Baños.

Breeding Much of the varietal improvement in melon is based on mass and line selection in open-pollinated populations. However, these are now rapidly giving way to F_1 hybrid cultivars, especially in Europe, United States, Japan and Taiwan. Pure-line development in melon is easy, as there is practically no inbreeding depression after repeated selfing. On the other hand, there is also little hybrid vigour in hybrids between inbred lines. The main advantages of F_1 hybrids are, however, uniformity of plant and fruit type and combination of favourable characters of different melon types in one genotype: fruit quality (round shape, good flavour, high sugar content, small seed cavity), long shelf life, adaptation to more humid climates

and especially resistance to diseases and pests.
Most cultivars are andromonoecious and F_1 hybrid seed production requires emasculation of the hermaphrodite flowers followed by hand pollination. Monoecious plant types would enable hybrid seed production with bee pollination, as the female line can be temporarily induced to become gynoecious (only female flowers) by sprays with ethrel. However, the change to monoecious F_1 hybrids is slowed down by the fact that monoecy in melons is linked to elongated shape and large size of the fruits, while the aim of most breeding programmes is round and compact fruits. However, in smooth-skinned 'Charentais' and Italian musk melons, monoecious F_1 hybrids are now becoming increasingly common. In South-East Asia, melon improvement is still in its initial stage.

Prospects Melon is well-liked by most people and the importance of this crop would increase further, including in South-East Asia, with better adaptation to hot and humid growing conditions. Another factor limiting melon production is the multitude of diseases (viruses in particular) and pests. However, new techniques from cellular (protoplast fusion) and molecular (genetic transformation, DNA markers) biology are now within reach of the melon breeders. This will open prospects of exploiting germplasm from other *Cucumis* species for disease and pest resistance and other characters, not available through conventional interspecific hybridization.

Literature |1| Odet, J. (Editor), 1991. Le melon. Ctifl, France. 293 pp. |2| Pitrat, M. & Risser, G., 1992. Le melon. In: Gallais, A. & Bannerot, H. (Editors): Amélioration des espèces végétales cultivées [Improvement of cultivated plant species]. Institut National de la Recherche Agronomique (INRA), Paris, France. pp. 448–459. |3| Purseglove, J.W., 1968. Tropical crops. Dicotyledons 1. Longman, London, United Kingdom. pp. 110–113. |4| Shinohara, S. (Editor), 1984. Vegetable seed production technology of Japan. Shinohara's Authorized Agricultural Consulting Engineer Office, Tokyo, Japan. Vol. 1. pp. 361–394. |5| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 156–159. |6| Whitaker, T.W. & Davis, G.N., 1962. Cucurbits: botany, cultivation and utilization. Leonard Hill, London, United Kingdom. 250 pp. |7| Yamaguchi, M., 1983. World vegetables: principles, production and nutritive values. Avi Publishing Company, Westport, Connecticut, United States. pp. 322–327.

M.M. Paje & H.A.M. van der Vossen

Cucumis sativus L.

Sp. pl.: 1012 (1753).
CUCURBITACEAE
$2n = 14$

Vernacular names Cucumber, gherkin (En). Concombre, cornichon (Fr). Indonesia: ketimun, mentimun (Javanese), bonteng (Sundanese). Malaysia: timun, mentimun. Papua New Guinea: kukamba, kuikamba. Philippines: pipino (Tagalog), kalabaga (Bisaya), kasimum (Bontoc). Burma: thakhwa. Cambodia: trâsâk. Laos: tèèng. Thailand: taeng-kwa (general), taeng-ran, taeng-om (northern). Vietnam: d[uw]a chu[ooj]t, d[uw]a leo.

Origin and geographic distribution *C. sativus* is not known from the wild. Although most *Cucumis* species have an African origin, *C. sativus* is believed to originate from the foothills of the Himalayas, where the closely related wild species *C. hardwickii* Royle still occurs. In India the cucumber was already being cultivated 3000 years ago, and it was known in ancient Egypt, Greece and the Roman Empire. In the 6th Century it was cultivated in China and was probably the first cultivated cucurbit to reach Malesia. Now it is cultivated worldwide.

Uses *C. sativus* is grown for the immature fruits which are used as a salad vegetable (slicing cucumber) and for pickles (gherkin). The slicing cucumbers are peeled, sliced and served with vinegar or dressing or as an ingredient of salads. The large, yellow types are boiled and eaten as an ingredient of stews. The young shoots are eaten raw or steamed, particularly in South-East Asia. In some areas ripe fruits are used for the preparation of jellies. In Irian Jaya (Indonesia), ripe cucumbers are often taken along by travellers on long foot trips to alleviate thirst. Seed kernels are sometimes consumed as a snack food and they also yield an edible oil.
Ripe raw cucumbers are said to be good for sprue, and in Indo-China cooked immature fruits are given to children to cure dysentery. The seed has some anthelmintic property.

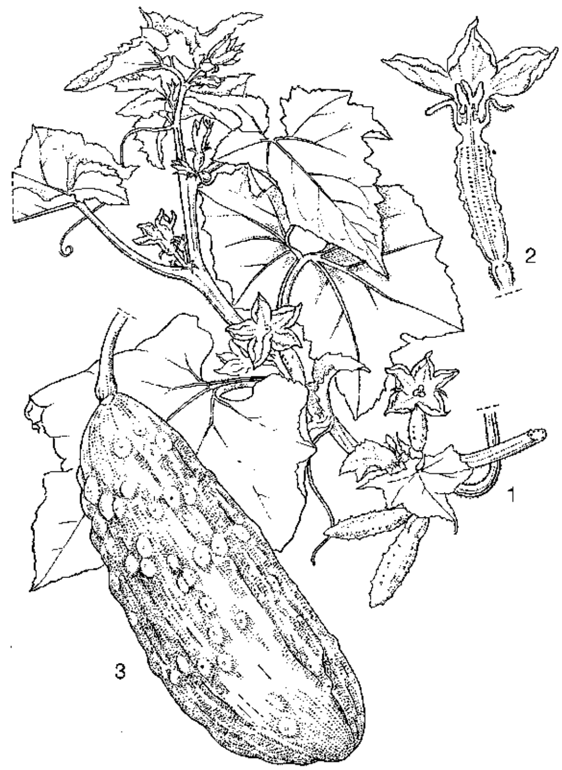
Production and international trade Compared with other vegetables, cucumber occupies fourth place in importance in the world, following tomato, cole crops and onion. In 1987 world acreage of *C. sativus* was estimated at about 850 000 ha with a total production of 12.5 million t; about half can be attributed to Asia, with China leading with 240000 ha and 3.7 million t. In South-East Asia the totals are: Indonesia (1988)

40000 ha, 291000 t; the Philippines (1987) 1000 ha, 6000 t; Thailand (1988) 12000 ha, 143000 t. Pickling cucumbers (gherkins) are not popular in South-East Asia. Small-size gherkins are produced in Indonesia for export because of the high labour costs for harvesting in western countries.

Properties Immature cucumber fruits have an edible portion of about 85%. Per 100 g edible portion they contain: water 96 g, protein 0.6 g, fat 0.1 g, carbohydrates 2.2 g, Ca 12 mg, Fe 0.3 mg, Mg 15 mg, P 24 mg, vitamin A 45 IU, vitamin B_1 0.03 mg, vitamin B_2 0.02 mg, niacin 0.3 mg, vitamin C 12 mg. The energy value is 63 kJ/100 g. Seed kernels contain approximately 42% oil and 42% protein. The weight of 1000 seeds is 20–35 g.
Cucurbitacins are terpene components in cucumber which cause a bitter flavour in foliage and fruits. As a result of breeding, modern cultivars are not bitter. The presence of a saponin and the slightly poisonous alkaloid hypoxanthine might explain the anthelmintic property of the seed.

Description A monoecious, annual, creeping or climbing herb, up to 5 m long, with stiff bristly hairs. Root system extensive and largely superficial. Stem 4–5-angled, sparingly branched, robust, with simple tendrils up to 30 cm long inserted opposite the leaves. Leaves alternate, simple, in outline triangular-ovate, 7–20 cm × 7–15 cm; petiole 5–20 cm long; leaf-blade 3–7-lobed, deeply cordate at base, acute at apex, lobes triangular, acute at apex, dentate. Flowers axillary, unisexual, occasionally hermaphrodite, 2.5–4 cm in diameter, yellow; male flowers predominating, borne in clusters of 3–7 on pedicels 0.5–2 cm long, stamens 3, free; female flowers solitary, on short thick pedicels 3–5 mm long, lengthening in fruit to 2–5 cm, style simple, stigmas 3, ovary 2–5 cm long; calyx campanulate, 5-lobed, 5–10 mm long, densely pubescent; corolla widely campanulate, deeply 5-lobed, up to 2 cm long, hairy, wrinkled. Fruit a pepo, pendulous, very variable in shape, size and colour, from nearly globular to cylindrical, often slightly curved, with scattered spinous tubercles and warts when young; spines black or white; flesh pale green, many-seeded (seedless in parthenocarpic cultivars). Seed flat, ovate-oblong in outline, 8–10 mm × 3–5 mm, white, smooth.

Growth and development Germination is epigeal and takes about 3 days at 25°C and 6–7 days at 20°C. The plants need a warm, frost-free period of 100–140 days from sowing to harvest. Flowering normally starts 40–45 days after sowing. Bees are the main pollinating agents. The female flowers develop later than the more numerous male flowers. The ratio of male to female flowers largely depends on daylength, temperature and cultivar. Generally, long days, high temperatures and other stress conditions tend to keep the plants in the staminate phase. Pruning, fertilizer application and hormone spraying are possible measures which can influence the sex ratio. Hand pollination assists fruit setting. However, the European forcing cucumber sets fruit parthenocarpically and pollination should be avoided, as seed set will cause ballooning at the fruit base.



Cucumis sativus L. – 1, flowering and fruiting shoot; 2, female flower (longitudinal section); 3, fruit.

Other botanical information *C. sativus* and *C. hardwickii*, each with $2n = 14$, are clearly distinct from all other *Cucumis* species, which have $2n = 24$. *C. hardwickii* hybridizes readily with *C. sativus*, producing a fertile F_1 and F_2, which suggests that it might be a progenitor of the cultivated cucumber. *C. hardwickii* is considered by some as a weedy form of *C. sativus* which has escaped from cultivation (*C. sativus* L. var. *hardwickii* (Royle) Alef.).
Numerous cultivars have been developed all over

the world, differing in size and shape of the fruits, in characteristics of the rind (thickness, spininess, colour), and in daylength sensitivity. These can be classified into two main groups:
- cv. group Slicing Cucumber: fruits of most current (hybrid) cultivars have white spines and uniform green exterior colour, are 15–25 cm long with a length/diameter ratio of more than 4 at time of harvest, e.g. 'Poinsett'. Older cultivars and landraces in Asia may have white, yellow or red-brown (e.g. Sikkim cucumber) skins, often with black spines. The gynoecious and parthenocarpic cucumber for greenhouse cultivation (fruits more than 30 cm long) is not popular outside Europe and Canada.
- cv. group Pickling Cucumber: fruit less than 12 cm long with a length/diameter ratio of 2.8–3.2, usually with white spines, older cultivars with black spines, on pronounced warts, green outer skin often slightly striped. It is used for processing into gherkins, mainly in the United States and Europe.

In Indonesia the most popular type of local cultivars is called 'ketimun biasa', 'ketimun wuku' (Javanese) or 'bonteng turus' (Sundanese). The fruits are small to medium sized, with a soft rind, not very elongated, white to green with scattered warts when young, brownish when mature. Very young fruits used for pickles. Other cultivars have big, smooth fruits, with a thick rind, warty and white to green when young, dark yellow when ripe.

The Oriental Pickling Melon (*Cucumis melo* L. var. *conomon* Makino) is often erroneously considered as a type of ordinary cucumber. In Indonesia, the young green fruits are called 'ketimun krai' and the mature fruits 'ketimun poan'.

Ecology Cucumber requires a warm climate. In cool temperate countries it is grown year-round in greenhouses or during the hottest summer months in the open. The optimum temperature for growth is about 30°C and the optimum night temperature 18–21°C. In the tropics, elevations up to 1000 m appear to be suitable for cucumber cultivation. An abundance of light tends to increase the number of staminate flowers. Sensitivity to daylenth differs per cultivar; short daylength usually promotes leaf and fruit production. Cucumbers need a fair amount of water but they cannot stand waterlogging. High relative humidity encourages downy mildew. The soil should preferably be fertile, well-drained, with a pH of 6.5–7.5.

Propagation and planting Cucumber is propagated by seed. Soil preparation requires generous incorporation of manure, about 30 t/ha. Sowing is done directly in the field with several seeds per hill, 90–120 cm apart, then thinned to 2–3 plants per hill, or seeds are sown in nursery beds and seedlings transplanted to the field at the 2-true-leaf stage at 30–40 cm within and 1–2 m between the rows. Sowing rates per ha are about 2.5–3 kg for direct seeding and 1 kg when transplanted. Cucumber cultivated for pickles is planted closer, up to 250 000 plants/ha.

Husbandry The crop responds well to fertilizers. In addition to the initial manure, about 700 kg/ha of an NPK mixture can be applied, followed by nitrogen fertilizer every 2–3 weeks until the fruits form. Excessive use of N promotes excessive vine growth and maleness. A good practice for the application of mineral fertilizer is: 6 g triple superphosphate (in addition to 1 kg farmyard manure) in each planting hole, 6 g per plant of a mixture of urea and KCl (1 : 1) two weeks after emergence, 6 g per plant of urea or 12 g of ammonium sulphate two weeks later and again when needed. Weed control is necessary until the plants cover the soil entirely. Support (stakes) should be provided for some cultivars, and the tip of the main stem may be nipped off to encourage branching. Irrigation is required at frequent intervals, and a high level of soil moisture should be maintained throughout the growing period. Lateral shoots may be pruned after the first fruits have formed to limit leaf and flower production.

Diseases and pests A very devastating disease of cucumber in South-East Asia is angular leafspot caused by the bacteria *Pseudomonas lacrymans*. It occurs under wet and humid conditions. Control with bactericides is too expensive and not really effective. The most important fungal diseases are downy mildew (*Pseudoperonospora cubensis*), powdery mildew (*Erysiphe cichoracearum*) and damping-off (*Pythium, Rhizoctonia*). Chemical sprayings, e.g. with carbamates, are used to control the mildews. Desinfection of seed with thiram, treatment of the planting holes and spraying of seedlings on emergence with a suitable fungicide (e.g. metalaxyl) control damping-off. Cucumber mosaic virus (CMV), papaya ring spot virus (PRSV-W) and zucchini yellow mosaic virus (ZYMV) cause much trouble. The use of disease-free seed and sprayings against aphids may keep virus diseases under control. Other pathogens reported to cause damage are anthracnose (*Colletotrichum*), fruit wet-rot (*Choanephora cucurbitarum*), *Fusarium* wilt, *Cladosporium* scab, bacterial soft rot (*Erwinia*), curly top virus

and root-knot nematodes (*Meloidogyne incognita*, *M. javanica*).
The most noxious insects are *Epilachna* beetles, greasy worm (*Agrotis ipsilon*), the melon fruit fly (*Dacus* spp.) and aphids. They are controlled with insecticides. The combat of pests with natural enemies is highly developed in greenhouses, but still has no practical application in open cultivation.

Harvesting Cucumbers for fresh consumption are harvested before they are fully mature, usually starting about 60 days after planting, and thereafter every few days. For pickling, immature fruits of several stages are harvested. Only for seed production are cucumbers allowed to mature on the plant.

Yield In 1987 average world yield for cucumbers reached 15 t/ha, but the range is wide and yields of 5–7.5 t/ha are considered reasonable. Yield figures for some South-East Asian countries are as follows: Indonesia (1988) 7.2 t/ha, Malaysia (1987) 2.1 t/ha, the Philippines (1987) 5.1 t/ha, Thailand (1988) 8.9 t/ha. In greenhouses in Europe yields of 350 t/ha are obtained.

Handling after harvest Cucumbers should be handled with care as they damage easily during transport. The maximum storage period is approximately 14 days at 13°C with a relative humidity of 95%. Below 10°C, chilling injury may occur and above 16°C fruits rapidly become yellow. Waxing or packaging in plastic film retards moisture loss. Pickling cucumbers are usually fresh-processed (quick pasteurization), or first brined and then processed.

Genetic resources Old cucumber cultivars of South-East Asia should be collected for conservation since they are gradually replaced by improved cultivars, mostly hybrid cultivars from seed companies. Important germplasm collections are available in the Czech Republic (Breeding Station, Kvetoslavov), Germany (Institute for Plant Cultivation and Plant Breeding, Braunschweig), India (Kerala Agricultural University, Trichur), the Netherlands (Centre for Genetic Resources, Wageningen), the Philippines (Institute for Plant Breeding, Los Baños), Turkey (AARIR, Menemen, Izmir), Russia (Vavilov Institute of Plant Industry, Petersburg), United States (NCRPIS, Iowa State University, Ames; NSSL, USDA-ARS Colorado State University, Colorado).

Breeding Slicing and pickling cucumber have been subject of intensive breeding work and genetic studies, particularly in the United States and in Europe. Much progress has been made with dramatically increasing yields and fruit quality, as well as with resistance to many important diseases and even some pests. The development of parthenocarpic, female and hybrid cultivars has led to very high yields, especially in greenhouse-grown cucumbers for fresh consumption. Most present day cultivars are F_1 hybrids based on at least one fully gynoecious line and on chemically regulated sex expression. Worldwide, cucumber research is mainly concentrated on issues like producing inexpensive hybrid seed through genetic manipulation of sex expression, disease and pest resistance, and the breeding of plant types with short internodes and large numbers of fruits that can be harvested mechanically. Hybridization with related wild species (e.g. *Cucumis hardwickii*) is a promising method to obtain new desirable characteristics.

Prospects Cucumber is very important in South-East Asia as it is in temperate regions. Breeding work should aim at producing improved cultivars with resistances to diseases and pests for tropical lowland conditions.

Literature |1| Bates, D.M., Robinson, R.W. & Jeffrey, C. (Editors), 1990. Biology and utilization of the Cucurbitaceae. Comstock, Cornell University Press, Syracuse, New York, United States. 485 pp. |2| Dixon, G.R., 1981. Vegetable crop diseases. MacMillan, London, United Kingdom. pp. 307–336. |3| Lower, R.L. & Edwards, M.D., 1986. Cucumber breeding. In: Bassett, M.J. (Editor): Breeding vegetable crops. Avi Publishing Company, Westport, Connecticut, United States. pp. 173–207. |4| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 191–194. |5| Purseglove, J.W., 1968. Tropical crops. Dicotyledons 1. Longman, London, United Kingdom. pp. 114–116. |6| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 159–161. |7| Seshadri, V.S., 1986. Cucurbits. In: Bose, T.K. & Som, M.G. (Editors): Vegetable crops in India. Naya Prokash Press, Calcutta, India. pp. 91–164.

B.H. Gildemacher & G.J. Jansen

Cucurbita L.

Sp. pl.: 1010 (1753); Gen. pl. ed. 5: 441 (1754).
CUCURBITACEAE
$x = 10$, $2n = 40$

Major species and synonyms

– *Cucurbita ficifolia* Bouché – see separate article.

- *Cucurbita maxima* Duchesne ex Lamk, Encycl. 2: 151 (1786).
- *Cucurbita mixta* Pangalo, Bull. Appl. Bot., Leningrad 23(3): 258 (1930), synonym: *C. argyrosperma* Bailey (1948).
- *Cucurbita moschata* (Duchesne ex Lamk) Duchesne ex Poiret, Dict. sci. nat. 11: 234 (1818), synonym: *C. pepo* L. var. *moschata* Lamk (1786).
- *Cucurbita pepo* L., Sp. pl.: 1010 (1753), synonyms: *C. fastuosa* Salisb. (1796), *C. subverrucosa* Willd. (1805), *C. esculenta* S.F. Gray (1821).

Vernacular names Pumpkin, winter squash, summer squash, marrow, cushaw, gourd (En). Courge, potiron, courgette (Fr). Indonesia: waluh, labu, labu merah. Malaysia: labu merah, labu parang. Papua New Guinea: pamkin. Philippines: kalabasa. Cambodia: lo-pëu. Laos: f'ak kh'am, f'ak th'oong, 'ü'. Thailand: fak-thong (central), namtao farang (peninsular). Vietnam: b[is] d[or], b[is] ng[oo].

Note: all these names may refer to any of the cultivated *Cucurbita* species. There is no clear discriminating vernacular nomenclature. See under 'Uses' for culinary differences.

Origin and geographic distribution The genus *Cucurbita*, comprising about 25 species, is of New World origin. Central Mexico is considered the centre of origin of *C. pepo*, *C. moschata* and *C. mixta*, and southern Peru, Bolivia and northern Argentina the centre of origin of *C. maxima*. Archaeological evidence for the association of cultivated *Cucurbita* with man date back to about 8000 BC. Wild forms have never been found. *C. pepo* mainly spread in northern direction (United States), *C. moschata* and *C. mixta* spread both north (United States) and south (Central and northern South America), whereas *C. maxima* remained confined to South America. After the discovery of the New World, *Cucurbita* species were introduced into the Old World, and secondary centres of diversity developed, mainly in Asia. There is little information on the relative importance of the 4 species in South-East Asia, but *C. moschata* seems to be the most common, due to its adaptation to the lowland tropics.

Uses Fruits, leaves and flowers of all 4 species are used as vegetable, and their seeds are consumed roasted as a snack food. There are numerous types and cultivars which differ greatly in composition and therefore in their suitability for certain culinary uses. The common names 'pumpkin' and 'squash' have no botanical significance, but should be used in a strictly culinary sense. 'Pumpkin' is the edible fruit of any of the *Cucurbita* species, utilized in the ripe stage for pies or as fodder; the flesh is somewhat coarse and rather strongly flavoured for use as a table vegetable. In contrast, 'squash' is the edible fruit of any of the *Cucurbita* species, utilized as a table vegetable; the flesh is fine-grained and mild-flavoured, and therefore also suitable for baking. 'Summer squash' applies to immature fruits (mainly *C. pepo*), 'winter squash' to mature fruits (all 4 species), the term 'winter' being used in the sense that the fruit may be stored for later use. The term 'marrow' (mainly used in Great Britain) is used for mature fruits of *C. pepo* and *C. maxima*, served boiled or stewed. The name 'cushaw' is confined to mature fruits of *C. mixta* used for baking or fodder. Immature and mature fruits of *C. moschata* in particular are used in South-East Asia as a blanched, steamed or fried vegetable and as an ingredient of soups. Various desserts are made from the fruits: steamed flesh with grated coconut and sugar, crisps made from steamed meshed flesh mixed with cassava flour, pumpkin custard, pumpkin pudding, pumpkin in coconut milk and sweet pumpkin paste.

Ornamental gourds are cultivars of *C. pepo* with small, bitter and inedible fruits in many shapes, sizes and colours. The potential of the seeds as a source of vegetable fat and protein has not been fully exploited. Fresh seeds have been reported to be used as a vermifuge, and seed decoctions as diuretic and to reduce fevers.

Production and international trade World production of pumpkin and squash in 1988 is estimated at 6346000 t. In South-East Asia, where they are produced for local markets, production is estimated at 217000 t.

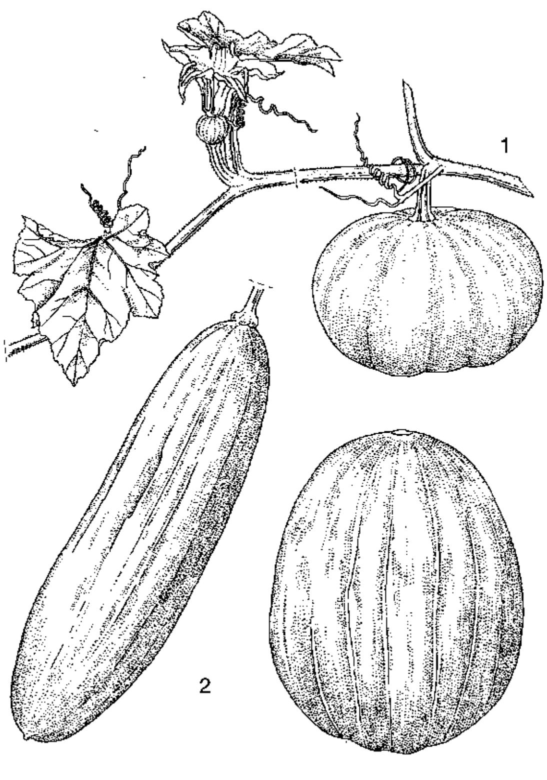
Properties The edible portion of pumpkin and winter squash (mature fruits) varies from 60–85%. They are good sources of vitamin A. Per 100 g edible portion, they contain: water 85–91 g, protein 0.8–2.0 g, fat 0.1–0.5 g, carbohydrates 3.3–11.0 g, vitamin A 340–7800 IU, vitamin B_1 0.07-0.14 mg, vitamin B_2 0.01–0.04 mg, niacin 0.5–1.2 mg, vitamin C 6–21 mg, Ca 14–48 mg, Fe 70 mg, Mg 16–34 mg, P 21–38 mg. The energy value is 85–170 kJ/100 g.

Summer squash (immature fruits of *C. pepo*) is slightly less nutritious because it contains more water, but it has less waste. The seed kernels contain 40–50% oil and 30% protein.

Pumpkins and squashes contain cholinesterase inhibitors, and summer squash has been reported to contain glycosides called cucurbitacins, causing bitterness.

The 1000-seed weight is about 80 g for *C. moschata*, and 200 g for *C. maxima*, *C. mixta* and *C. pepo*.

Description Monoecious annual or short-lived perennial scandent herbs. Stem long-running or short and bushy, more or less scabrous, soft to hard, round to angular, often rooting at the nodes. Tendrils branched. Leaves simple, alternate, long petiolate; leaf-blade broadly cordate to triangular in outline, shallowly to deeply lobed, often with whitish blotches, more or less rigid and scabrous. Flowers solitary, large, showy, lemon yellow to deep orange; calyx and corolla campanulate; staminate flowers on long pedicels, stamens 3, anthers usually connivent into a long twisted body, filaments partly free; pistillate flowers on short pedicels, with ovary oblong or discoid, unilocular and style thick with 3 two-lobed stigmas. Fruit a pepo; fruit stalk soft to hard, round to angular, thickened with soft to hard cork, enlarged or not at point of attachment of the fruit. Seeds numerous, flattened, usually white or tawny, sometimes dark-coloured.



Cucurbita moschata (Duchesne ex Lamk) Duchesne ex Poiret – 1, flowering and fruiting shoot; 2, fruit types.

- *C. maxima*. Vine or rarely bush. Stem soft and round. Leaves neither rigid nor prickly, nearly orbicular in outline, serrate, not or only shallowly lobed, but with a deep sinus at the base. Corolla lobes curved outwards. Fruit stalk soft, spongy, nearly cylindrical, strongly thickened by soft cork, not enlarged at the point of attachment of the fruit.
- *C. mixta*. Vine. Stem hard, 5-angled, grooved. Leaves softly hairy or glabrous, not harsh, large, broadly cordate, shallowly to moderately lobed. Fruit stalk hard, strongly thickened by hard cork, not enlarged at fruit attachment.
- *C. moschata*. Vine. Stem hard and angular. Leaves softly hairy, not harsh, large, shallowly lobed. Corolla with widely spreading, mostly reflexed lobes. Fruit stalk hard, smoothly grooved, enlarged at fruit attachment.
- *C. pepo*. Vine or bush. Stem hard and angular. Leaves prickly through spiculate bristles, more or less rigid, broadly triangular, deeply and acutely lobed. Corolla with erect or spreading lobes. Fruit stalk hard, sharply 5-angled, grooved, not enlarged at fruit attachment.

Growth and development Germination is epigeal. Seeds germinate in about one week from sowing. They have extensive fibrous root systems and indeterminate growth habit. Under suitable conditions, they will continue to grow indefinitely when the trailing stems are permitted to root at the nodes. Vines may reach a length of more than 15 m. This does not apply to the bushy cultivars of *C. pepo* and *C. maxima*, which have short, semi-erect stems, due to short internodes.

Flowering is more or less continuous, the ratio of male to female flowers being influenced by growing conditions. Pollination is effected by insects, mainly bees, so they are predominantly cross-pollinated.

Squashes grown for the immature fruits produce the first harvest 7–8 weeks after planting and continue bearing for several months; those grown for mature fruits take 3–4 months until harvesting. The four species described here are all cultivated as annuals.

Other botanical information There is some confusion about the identity of the cultivated *Cucurbita* species. The fact that all species are often indicated by the same vernacular names (pumpkin and/or squash) contributes considerably to this confusion; if a certain species is meant, it is necessary to add the scientific name to the vernacular.

The great variability of most species, especially visible in their fruits, has led to numerous subspecific classifications. However, it is preferable to develop classifications directly based on cultivar characteristics below the species level.

- *C. maxima*. Some proposed cultivar groups are: Mammuth (synonym: *C. maxima* ssp. *maxima* convar. *maxima*), Banana (synonym: *C. maxima* ssp. *maxima* convar. *bananina* Grebenscikov), Hubbard (synonym: *C. maxima* ssp. *maxima* convar. *hubbardina* Grebenscikov), Turban (synonym: *C. maxima* ssp. *maxima* convar. *turbaniformis* (Roem.) Alef).
- *C. mixta*. Botanically it has been long included in *C. moschata*, but sterility barriers are effective enough to maintain its identity. Genetically it seems closest to *C. pepo*. It is not of such ancient cultivation as *C. maxima* and *C. pepo*. Cultivars include 'Cushaw', 'Japanese Pie', 'Silverseed Gourd'.
- *C. moschata*. The species most widely grown throughout the tropics, Cultivars include 'Butternut', 'Kentucky Field', 'Sugar', 'Winter Crookneck'.
- *C. pepo*. Some proposed cultivar groups are (for the edible forms): Pumpkin, Scallop, Acorn, Crookneck, Straightneck, Vegetable Marrow, Cocozelle and Zucchini. The inedible ornamental forms could be grouped in cv. group Ornamental Gourd (synonyms: *C. ovifera* L., *C. pepo* var. *ovifera* Alefeld, *C. pepo* ssp. *pepo* convar. *microcarpina* Grebenscikov). Another subclassification of *C. pepo* divides the cultivated forms into two groups: the *longicaules* group sensu Grebenscikov with running or climbing stems and the *brevicaules* group sensu Grebenscikov with non-running, bushy growth.

C. texana A. Gray is a wild species occurring in the United States (Texas) and is considered as the archetype of *C. pepo*; sometimes it is classified as a taxon within *C. pepo* (e.g. *C. pepo* ssp. *texana* (Scheele) Filov).

Ecology Pumpkins and squashes are grown in the tropics from the lowlands up to 1500 m altitude. They are warm season crops adapted to monthly mean temperatures of 18–27°C. *C. maxima* is the most tolerant of low temperatures, *C. moschata* and *C. mixta* the least, with *C. pepo* in an intermediate position. *C. maxima* and *C. pepo* have long been cultivated in temperate regions.

All 4 species are relatively insensitive to photoperiod, although both photoperiod and temperature influence the ratio of male to female flowers (long days and high temperatures favouring male sex expression).

Pumpkins and squashes are not very demanding with respect to soil requirements. They can be cultivated on almost any fertile, well-drained soil with a neutral or slightly acid reaction (pH 5.5–7). They are drought-tolerant, requiring relatively little water, and are sensitive to waterlogging. Excessive humidity is harmful because of the development of leaf diseases, so none of the species does well in the humid tropics.

Propagation and planting Pumpkins and squashes are grown from seed. They can be grown from cuttings if required, as they root at the nodes, but this method is not used in commercial practice. Seeds may be sown in containers and transplanted to the field when they are 10 cm high. Direct-seeding of 2–3 seeds per hill is commonly practised. Trailing types are planted at distances of 2–3 m either way; the seed requirement is 2–3 kg/ha. The bushy types (mainly *C. pepo*) are planted closer, e.g. plants spaced 60–120 cm in rows 1–1.5 m apart; the seed requirement is 3 kg/ha for pumpkin and 7 kg/ha for summer squash. Plant densities vary from 5000 plants/ha for the long-running trailing forms to 20 000 plants/ha for the bushy types.

Husbandry In South-East Asia pumpkins and squashes are often planted in home gardens or mixed with field crops such as maize. Sole cropping is sometimes used for commercial production. The bushy types are mainly restricted to commercial gardens.

They grow well on organic matter and are often encountered on compost or refuse heaps. They respond well to side dressings of liquid manure.

It is recommended to split-apply N 100 kg/ha, P 40 kg/ha and K 80 kg/ha, during the vegetative phase.

Other cultural practices to improve growth and development are the removal of growing tips to check growth, and the bagging of fruits in paper to protect against fruit fly and other pests. Fruit setting may be stimulated by manual pollination, but this practice is not very common.

Diseases and pests Anthracnose caused by *Colletotrichum lagenarium* is the most destructive disease. It causes defoliation and lesions on the fruits. Other diseases, mainly affecting the leaves and stems, are powdery mildew (*Erysiphe cichoracearum*), downy mildew (*Pseudoperonospora cubensis*, scab (*Cladosporium cucumerinum*), and leaf-spot (*Alternaria cucumerina*). *Choanephora cucurbitarum* causes wet rot of fruits. Important virus diseases are cucumber mosaic (CMV), watermelon mosaic (WMV-2), papaya ring spot

(PRSV-W), zucchini yellow mosaic (ZYMV) and squash leaf curl (SLCV).
The leaf-feeding *Epilachna* beetles are a serious problem for *Cucurbita* growers. Other troublesome pests are the squash vine borer *Melittia satyriniformis* and the pickle worm *Diaphania nitidalis*, apart from aphids, fruit flies, and various leaf beetles.

Harvesting The summer squashes (mainly *C. pepo*), from which the immature fruit is used as a fresh vegetable, develop very rapidly. The first marketable fruits can be harvested 50–60 days after planting, or 2–6 days after anthesis of the female flower. During the harvest season the plants are visited 2–3 times per week.
Winter squashes are picked when mature in a once-over harvest or in several rounds, about 90–120 days after planting.

Yield Crop yields for summer squash (immature fruits) are 7–12 t/ha, whereas 20–25 t/ha are normal yields for winter squash (mature fruits). The number of mature fruits harvested per plant is usually low, and the weight of individual fruits varies widely from 1–15 kg.
Winter squash (the baking types) and pumpkins are considered to be among the most efficient of vegetable crops when evaluated on nutritional yield in relation to land area and labour needed. Summer squash scores much lower in this respect. Indicative figures for seed yield of *C. pepo* are 400–1500 kg/ha. A valuable source of oil and protein is thus neglected if the seeds are left unutilized. In seed production, isolation between fields of different *Cucurbita* species is recommended, not only for reason of purity but also for obtaining maximum yields (pollen of other species may cause reduced fruit set or parthenocarpic fruits).

Handling after harvest Mature fruits of winter squash and pumpkin can be cured (healing of wounded tissue by suberization) in the sun, or under controlled conditions of 27–29°C and 80–85% relative humidity for 10 days. Properly cured, the mature fruits can be stored at 10–13°C and 70–75% relative humidity for up to 6 months without serious deterioration. Chilling injury may occur at temperatures below 10°C. The flesh is often dried in strips for later use in soups and stews. Pumpkins are as a rule canned for the bakery trade. Summer squash can be kept for up to 14 days when stored at 7–10°C and 85–95% relative humidity.

Genetic resources *Cucurbita* spp. are well represented in the cucurbit germplasm collections of many institutions all over the world. Important base collections are maintained by the National Seed Storage Laboratory (NSSL), Fort Collins, Colorado, United States, and by the Vavilov Institute of Plant Industry (VIR), Petersburg, Russia.
In South-East Asia, the largest *Cucurbita* collection is maintained by the National Plant Genetic Resources Laboratory (NPGRL), Institute of Plant Breeding, Los Baños, the Philippines. *C. moschata* is the dominant species. Relatively little attention has been given to the tropical types, and with the introduction of modern cultivars, ancient tropical landraces are certainly in danger of disappearing.

Breeding Squashes and pumpkins are entomophilous and although self-compatible, they are naturally cross-pollinated. Inbreeding causes little loss of vigour, whereas a considerable degree of heterosis has been observed.
Considerable breeding work has been done in the United States and Europe, and many cultivars and types have been developed, mainly in *C. maxima* and *C. pepo*. The Zucchini cultivar group of *C. pepo* is most advanced in combining horticulturally valuable characteristics such as open bushy growth habit (facilitating repeated harvesting), smoothness of foliage, and intense coloration.
High-yielding hybrid cultivars are now becoming popular. Several small-fruited cultivars, generally known as Japanese pumpkins, have been developed more recently in Japan. They have excellent culinary and storage properties.
No natural interspecific hybrids between the cultivated *Cucurbita* species have ever been observed. Crosses, however, can be obtained with varying degrees of difficulty. There is a potential for gene flow through backcrosses or the development of new amphidiploid crops. Results of interspecific hybridization suggest that the sterility barriers are genic rather than the result of a lack of chromosomal homology, which means that heterozygosity improves the chances of obtaining interspecific hybrids.
About 30 genes known to control qualitative characters have been described in the cultivated *Cucurbita* species. Desirable traits are available in related wild species, such as powdery mildew resistance in *C. lundelliana* Bailey.

Prospects The cultivated *Cucurbita* species make valuable contributions to the food resources of South-East Asia and will continue to do so in the future. Because relatively little attention has been given to the tropical types, germplasm collection of South-East Asian landraces deserves priority. Besides development of improved vegetable cultivars, attention should also be paid to the potential of the seed as a source of vegetable fat and protein.

Literature |1| Decker, D.S., 1988. Origin(s), evolution, and systematics of Cucurbita pepo (Cucurbitaceae). Economic Botany 42: 4–15. |2| Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 276–296. |3| Paris, H.S., 1989. Historical records, origins, and development of the edible cultivar groups of Cucurbita pepo (Cucurbitaceae). Economic Botany 43: 423–443. |4| Singh, A.K., 1979. Cucurbitaceae and polyploidy. Cytologia 44: 897–905. |5| Tisbe, V.O., Deanon Jr, J.R. & Bantoc Jr, G.B., 1967. The cucurbits. In: Knott, J.E. & Deanon Jr, J.R. (Editors): Vegetable production in South-East Asia. University of the Philippines Press, Los Baños, the Philippines. pp. 138–166. |6| Whitaker, T.W. & Bemis, W.P., 1975. Origin and evolution of the cultivated Cucurbita. Bulletin of the Torrey Botanical Club 102: 362–368. |7| Whitaker, T.W. & Bohn, G.W., 1950. The taxonomy, genetics, production and uses of the cultivated species of Cucurbita. Economic Botany 4: 52–81. |8| Whitaker, T.W. & Robinson, R.W., 1986. Squash breeding. In: Bassett, M.J. (Editor): Breeding vegetable crops. Avi Publishing Company, Westport, Connecticut, United States. pp. 209–242.

E.A. Widjaja & S. Sukprakarn

Cucurbita ficifolia Bouché

Verh. Ver. Beförd. Gartenb., Berlin 12: 205 (1837).

CUCURBITACEAE

$2n = 40$

Synonyms *Cucurbita melanosperma* A. Braun (1824), *Pepo ficifolia* Britton (1925).

Vernacular names General: all names like pumpkin and squash mentioned in the article on *Cucurbita* L. may also refer to this species. More specific names are: fig-leaf gourd, Malabar gourd, black-seeded squash (En). Courge de Siam, melon de Malabar (Fr).

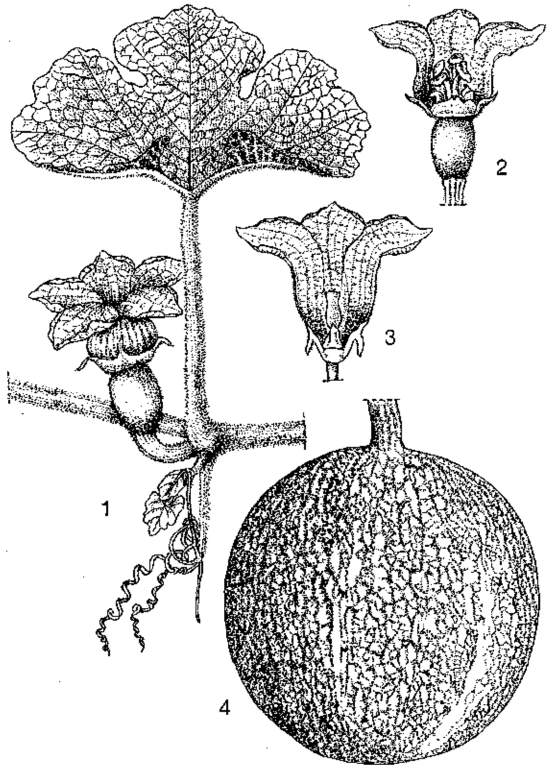
Origin and geographic distribution *C. ficifolia* is a cultigen which probably originated in Central Mexico and mainly spread to South America with an ecological preference for highland areas (high plateaus of Central America and along the Andes to central Chile). The first fruits to reach Europe apparently took a circuitous route from South America to the Malabar Coast of India along the much travelled trade routes in the 16th and 17th Centuries, hence the vernacular names in English and French. In South-East Asia it is only grown in the highlands of Luzon, the Philippines, at an elevation of 1700 m above sea-level.

Uses Fig-leaf gourd is mainly grown for its large fruits. The tender immature fruits are used like summer squash or cucumber. The flesh of the mature fruits is often impregnated with sugar, and the resulting product used as candy or 'dulce'. It may also be fermented to make an alcoholic beverage. The young leaves and vine tips may be prepared as a green vegetable. The male flowers and buds are used in soups, stews and salads. In some areas, the raw or roasted seeds are eaten as a snack food. Fig-leaf gourd is also cultivated for its ornamental watermelon-like fruits and abundant foliage. It became popular in western countries as a rootstock for winter production of greenhouse cucumber due to its cold tolerance and good resistance to soilborne pathogens.

Production and international trade The main production area of *C. ficifolia* is Central and South America. It is only of local importance in South-East Asia, i.e. in the Philippines. No production statistics are available.

Properties The composition of *C. ficifolia* is comparable to mature fruits of other *Cucurbita* species, and lies in the following range (per 100 g edible portion): water 85–91 g, protein 0.8–2.0 g, fat 0.1–0.5 g, carbohydrates 3.3–11.0 g, vitamin A 340–7800 IU, vitamin B_1 0.07–0.14 mg, vitamin B_2 0.01–0.04 mg, niacin 0.5–1.2 mg, vitamin C 6–21 mg, Ca 14–48 mg, Fe 7.0 mg, Mg 16–34 mg, P 21–38 mg. The energy value is 85–170 kJ/100 g. The fruit pulp contains a proteolytic enzyme that has potential value in the food industry. The seeds are the most nutritious part of the fruit; they are rich in protein and oil. The weight of 1000 seeds is 180–250 g.

Description A monoecious, short-lived perennial vine, herbaceous but becoming somewhat woody. Taproot up to 2 m long, lateral roots forming a network slightly below the soil surface. Stem with numerous runners, up to 10 m long, prickly or spiny, hard, smoothly 5-angled to rounded, often rooting at the nodes; tendrils long, branched. Leaves simple, alternate; leaf-blade circular-ovate to nearly reniform in outline, 18–25 cm in diameter, sinuate to lobed and with obtuse sinuses, margins apiculate-serrate to entire. Flowers solitary, yellow to light orange, up to 7.5 cm in diameter; calyx and corolla campanulate with short tube; staminate flowers with short, thick and columnar androecium, filaments with trichomes more than



Cucurbita ficifolia Bouché – 1, flowering shoot; 2, female flower (in longitudinal section); 3, male flower (in longitudinal section); 4, fruit.

1 mm long; pistillate flowers on short, ridged pedicels with small, smooth, pale yellow gynoecium. Fruit a pepo, globular to cylindrical, 15–50 cm long, white to green with white stripes and blotches, rind smooth, hard; flesh white, coarse, tough, fibrous and rather dry; fruit stalk hard, round to 5-angled, without cork development, not or only slightly enlarged at point of fruit attachment. Seed flattened, oblong-ellipsoidal, 1.5–2.5 cm long, length to width ratio of 3 : 2, hard, without a spongy epidermis, black or sometimes light buff-coloured.

Growth and development Most forms of fig-leaf gourd require a short photoperiod for flowering and are normally very late in flowering compared to other species. Bees are the main pollinating agents and in South America, squash and gourd bees are specialized in pollinating *Cucurbita* species, including *C. ficifolia*. There are even indications that a certain bee species (*Peponapis atrata*) is restricted to the pollen of *C. ficifolia*. It takes approximately 16 weeks from anthesis to seed maturity. Under suitable growing conditions, fig-leaf gourd behaves like the other *Cucurbita* species and will continue to grow indefinitely when the stems are permitted to root at the nodes. However, it is usually grown as an annual.

Other botanical information In the taxonomic literature, 3 characteristics are often mentioned to distinguish *C. ficifolia* from the other cultivated *Cucurbita* species: perennial growth habit, leaf shaped like a leaf of the fig (*Ficus carica* L.), and black seeds. Those characteristics can be misleading because *C. ficifolia* does not differ in longevity from the other squash species, the fig-leaf form also occurs in other species, and the seeds are not always black. Most diagnostic are the following characteristics: the presence of trichomes on the filaments in the male flowers, and the shape of the seeds (length to width ratio of 3 : 2, which is broader than in other cultivated cucurbitas). Some well-known cultivars are 'Fig-leaf Gourd', 'Malabar Gourd', 'Lacayote' and 'Silacayote'.

Ecology Among the cultivated *Cucurbita* species, *C. ficifolia* has the most restricted habitat. In the high-altitude tropics where it is grown, it will often maintain vigour through cool humid periods while the other species perish because of limited cold tolerance. In South and Central America it is usually grown between 1000–2800 m above sea-level. It requires a short photoperiod for flower initiation, but day-neutral cultivars have also been reported. *C. ficifolia* is moderately tolerant to acid conditions and grows successfully in fertile, well-drained soils with a pH range of 6.5–7.5.

Propagation and planting Propagation is by seed. For seed germination, soil temperatures should be above 15°C; the germination percentage is highest at 35°C. Seed can be sown in flats, flat ridges or on mounds or hills. The seed rate is 2–4 kg/ha depending on the desired plant density. It is normal practice to sow 3 seeds per hill and thin to one seedling after emergence. Seeds are planted 2–5 cm deep, depending on the soil texture. Plant densities vary from 1000–6000 plants/ha. Fig-leaf gourd is usually grown on small acreages or in home gardens, and occasionally as an intercrop in maize.

Husbandry Fig-leaf gourd responds well to applications of up to 30 t/ha of organic manure during site preparation; additional application of inorganic fertilizers (110 kg/ha N, 40 kg/ha P, 90 kg/ha K) is beneficial. Trickle or furrow irrigation is preferable above sprinkler irrigation as any moisture on the leaves increases the incidence of leaf diseases.

Diseases and pests Diseases observed include leaf and stem rot (*Alternaria* spp.), watery soft rot (*Sclerotinia sclerotiorum*), leaf and stem spot (*Stemphyllium* spp.), bacterial leaf-spot (*Xanthomonas cucurbitae*), powdery mildew (*Erysiphe chicoracearum*) and virus diseases (cucumber, melon, squash, watermelon mosaic viruses), but *C. ficifolia* is a hardy crop. For virus diseases, it is important to use virus-free seed, to remove infected plants early, and to control the vectors.
The major insect pests include squash yellow beetle (*Aulocophora similis*), whitefly (*Bemisia tabaci*) and aphids (*Aphis* sp.), all of which are important vectors of viruses. Sanitation practices and the use of chemicals will help to control the pests.

Harvesting Fruits are allowed to mature on the vine. In temperate climates, if the fruits are mature, the rind is hard and the vines senesce; the fruits should be harvested before the occurrence of frost. In the tropics, the plants continue their growth and harvestable fruits must be selected. A sharp knife is used to cut the fruit stalk 2–5 cm from the fruit. Fruits are selected for uniform size, shape and colour.

Yield A yield of over 50 t/ha mature fruit can be realized under optimal conditions.

Handling after harvest Cuts and bruises of mature fruits can be healed by suberization. This is accomplished at 27–30°C and 80% relative humidity for a period of 10 days. Mature fruits can be stored for up to 6 months at 10–15°C and 60% relative humidity without much loss of quality.

Genetic resources *C. ficifolia* is the least variable of the cultivated *Cucurbita* species. It is represented by varying numbers of accessions in the *Cucurbita* collections of many institutions, in particular in Central and South America (CATIE, Turrialba, Costa Rica; San Carlos University, Guatemala; INIFAP, Celaya, Mexico), in the United States (Southern Regional Plant Introduction Station, Georgia) and in Russia (Vavilov Institute of Plant Industry, Petersburg). The one sizable collection in South-East Asia is at the Institute of Plant Breeding, the Philippines.

Breeding There have been no breeding programmes for the improvement of *C. ficifolia*. Although the cultivated *Cucurbita* species have developed a sequence of sterility barriers that prevents gene flow, *C. ficifolia* is potentially valuable for squash breeding. It is resistant to several viruses, shows some tolerance to powdery mildew, has the ability to grow under cool, moist conditions, and the mature fruits have long storage life without refrigeration. *C. ficifolia* can be hybridized with the other squash species by the use of embryo culture.

Prospects Fig-leaf gourd has good potential as a fresh vegetable in the tropics, in particular at higher elevations. So far, it has a very limited distribution in South-East Asia. A detailed study of this crop will provide a better understanding of its cultivation and potential. In addition, it has valuable characteristics (disease resistance, cold tolerance, long storage life of the fruits) for squash breeding in general.

Literature |1| Andres, T.C., 1990. Biosystematics, theories on the origin, and breeding potential of Cucurbita ficifolia. In: Bates, D.M., Robinson, R.W. & Jeffrey, C. (Editors): Biology and utilization of the Cucurbitaceae. Comstock, Cornell University Press, Syracuse, New York, United States. pp. 102–119. |2| Esquinas-Alcazar, J.T. & Gulick, P.J., 1983. Genetic resources of Cucurbitaceae. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 101 pp. |3| Hurd, P.D., Linsley, E.C. & Whitaker, T.W., 1971. Squash and gourd bees (Peponapis xenoglossa) and the origin of the cultivated Cucurbita. Evolution 25: 218–234. |4| Whitaker, T.W. & Bohn, G.W., 1950. The taxonomy, genetics, production and uses of the cultivated species of Cucurbita. Economic Botany 4: 52–81. |5| Whitaker, T.W. & Knight, R.J., 1980. Collecting cultivated and wild cucurbits in Mexico. Economic Botany 34: 312–319. |6| Whitaker, T.W. & Robinson, R.W., 1986. Squash breeding. In: Bassett, M.J. (Editor): Breeding vegetable crops. Avi Publishing Company, Westport, Connecticut, United States. pp. 209–242. |7| Yamaguchi, M., 1983. World vegetables: principles, production and nutritive values. Avi Publishing Company, Westport, Connecticut, United States. pp. 330–336.

V.P. Roxas

Daucus carota L.

Sp. pl.: 242 (1753).
UMBELLIFERAE
$2n = 18$

Synonyms *Daucus gingidium* L. (1753).

Vernacular names Carrot (En). Carotte (Fr). Indonesia: wortel, bortol (Sundanese). Malaysia: boktel, lobak merah. Papua New Guinea: karot, yalow pela sayor. Philippines: karot. Cambodia: karôt. Thailand: khaerot. Vietnam: c[af] r[oos]t.

Origin and geographic distribution It is

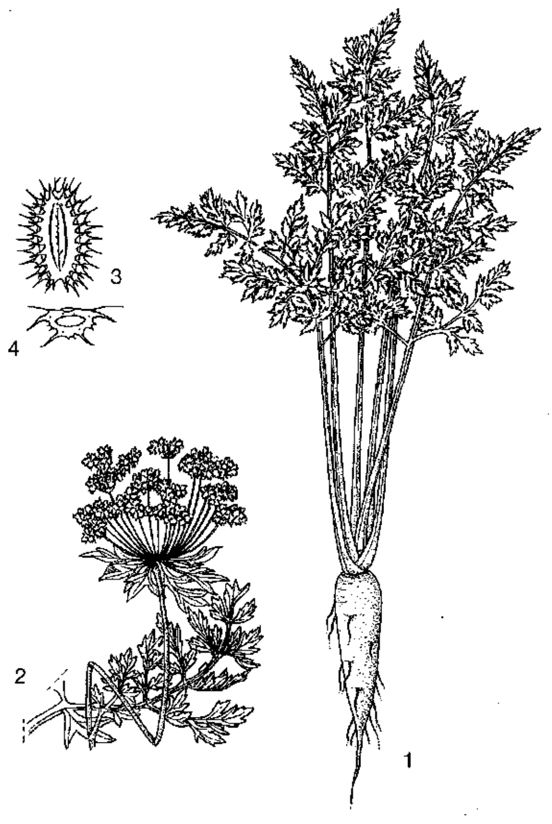
generally assumed that the purple (anthocyanin-containing) carrot originated in Afghanistan in the region where the Himalayan and Hindu Kush mountains are confluent, and that it was domesticated also in Afghanistan and adjacent regions of Russia, Iran, India, Pakistan and Anatolia. Purple carrot, together with a yellow variant, spread to the Mediterranean area and Western Europe in the 11–14th Centuries, and to China, India and Japan in the 14–17th Centuries.
The orange (carotene-containing) carrot probably arose in Europe or in the western Mediterranean region through gradual selection within yellow carrot populations. The Dutch landraces Long Orange and the finer Horn types were the basis for the orange carrot cultivars grown at present all over the world. In Asia they have now largely replaced the purple and yellow types because of superior taste and nutritional value.

Uses Carrot is the swollen taproot of *D. carota* and is an important market vegetable, even in tropical areas. The roots are consumed raw or cooked, alone or in combination with other vegetables (e.g. peas), as an ingredient of soups, sauces and in dietary compositions. Young leaves are sometimes eaten raw or used as fodder.

Production and international trade World area under carrot cultivation is at least 600 000 ha producing yearly 13 million t: 250 000 ha in Asia, 110 000 in the former Soviet Union, 60 000 ha in Eastern Europe, 70 000 ha in the European Community, 70 000 ha in the Americas, and 30 000 ha in Africa. In Indonesia in 1988 there were 10 500 ha of carrot, all in highland regions. Carrot is an important vegetable in China (120 000 ha), India (60 000 ha), Japan (25 000 ha), South Korea (5000 ha) and Taiwan (3000 ha). All carrot production in Asia is for local markets.

Properties Orange carrot has a good nutritional value, particularly a high carotene content. Per 100 g, fresh roots contain: water 87–91 g, protein 1 g, carbohydrates (sugar) 6–9 g, fibre 1 g, ß-carotene 6–20 mg, vitamin C 5–10 mg, Ca 40 mg, Fe 1 mg. The energy value is 120–170 kJ/100 g.
The seed in particular contains an essential oil, giving it a characteristic odour. Terpenoids and other volatile compounds influence the flavour of raw carrots. An astringent taste of carrots is caused by a high terpolene content in combination with a low percentage of sugars. The bitter taste of carrots after long storage is caused by the conversion of phenols into iso-coumarin under the influence of exogenous ethylene.
The 1000-seed weight is 0.6–2.2 g.

Description Annual or biennial erect herb, 20–50 cm tall at the mature vegetative stage and 120–150 cm tall when flowering. Taproot fleshy, straight, conical to cylindrical, 5–50 cm long and 2–5 cm in diameter at top, orange (most common), reddish-violet, yellow or white; the core (xylem) of mature roots is usually somewhat lighter in colour than the phloem, and the top of the root is often green. Leaves 8–12, growing in a rosette, glabrous, green, with long petiole often sheathed at its base; leaf-blade 2–3-pinnate, the segments divided into often linear ultimate lobes. Flowering stalks few to several, branched, each branch ending in a compound umbel (inflorescence); each umbel comprising 50 or more umbellets, each of which has up to ca. 50 flowers; involucral bracts more or less pinnatipartite; primary rays 2–25 cm, secondary rays 1–6 cm, pedicels 0.5–1.5 cm long; flowers mainly bisexual in primary umbels, in umbels of higher order an increasing number of male flowers may occur in addition to bisexual flowers; a few purple-red sterile flowers may be



Daucus carota L. – 1, habit; 2, flowering and fruiting shoot; 3, fruit (schizocarp); 4, seed (mericarp).

present in the central umbellets, especially in wild plants; flower small, 2 mm in diameter, epigynous, white, 5-merous but with 2 carpels and 2 styles. Fruit an oblong-ovoid schizocarp, 2–4 mm long, at maturity splitting into 2 mericarps, primary ridges ciliate, secondary ridges with hooked spines. Seed (inside the mericarp) with a long embryo embedded in endosperm. Seedling with long, thin taproot, cordate cotyledons and pinnate first true leaves.

Growth and development Carrot seed will remain viable (70–80% germination) for 6–7 years when stored dry (moisture content 9%) at temperatures below 18°C. Germination is epigeal with first appearance of seedlings 9–12 days after sowing. The first four true leaves are formed at 4 to 5-day intervals, starting 3–4 weeks after sowing, but then the interval increases gradually to 15–18 days for subsequent leaves. A thin taproot grows down vertically to 20–25 cm, and 30–40 days after germination it starts swelling and gradually turning orange (in carotene carrots) from the hypocotyl stem downwards. About 80% of all carbohydrates produced in the plant are diverted to the root during this stage of development.

The roots are mature 70–120 days after sowing according to the type of cultivar and growing conditions. The generative phase is induced by low temperatures. Carrot plants become sensitive to vernalization after the formation of at least eight leaves. The bolting-resistant cultivars of higher latitudes require 5–12 weeks at 2–6°C to induce bolting. Local cultivars grown in the tropics show bolting when the night temperatures drop below ca. 16°C. The generative phase is accelerated by long days after devernalization (20°C). First a new rosette of leaves is formed followed by elongation of the flowering stalk and first flowering 3 months later. Flowers are arranged in spirals and development is centripetal: the first mature flowers are on the outer edges of the outer umbellets. Flowering may last for one month, starting with the primary umbel. Initially the umbels are flat and concave. At anthesis the umbellets turn downwards progressively from the outside towards the centre, so that by the time the central flowers are mature, the umbels are more or less convex to conical. After pollination the umbellets turn upwards again.

Carrot is predominantly outbreeding due to protandry. Insects such as bees and flies, attracted by abundant nectar, effect cross-pollination. The stigma becomes receptive 2–3 days after pollen dehiscence. Petals drop soon after fertilization and the seeds (mericarps) are mature 40–50 days later.

Other botanical information *D. carota* is a complex, very variable species comprising wild and cultivated carrots. The variability has resulted in a confused taxonomy. At present the complex is subdivided into 13 subspecies, 12 for wild taxa and 1 for cultivated taxa (ssp. *sativus* (Hoffm.) Arc.). However, for cultivated taxa it is better to classify directly at cultivar level below the species level.

There are two main groups of cultivated carrot:

- the eastern (anthocyanin) carrot: roots branched, yellow, reddish-purple to purple-black, rarely yellowish-orange; leaves slightly dissected, greyish-green, pubescent; flowering in the first year;
- the western (carotene) carrot: roots unbranched, yellow, orange or red, occasionally white; leaves strongly dissected, bright green, sparsely hairy; normally biennial, but often annual in tropical regions.

At present the western carrot is by far the most important, although the eastern carrot is still cultivated in some Asian countries. Three main groups of western (carotene) carrot cultivars arose by selection in the 19th and early 20th Centuries in western Europe and the United States from the Dutch landraces 'Long Orange' and 'Horn':

- Early Short: 3–8 cm long globular-shaped roots, fine foliage; cultivars include 'Grelot', 'French Forcing', 'Parisian Market';
- Early Half-Long: 10–20 cm long cylindrical to conical roots, fine to medium foliage; cultivars include 'Amsterdam Forcing', 'Nantes', 'Vertou', 'Touchon', 'Sitan';
- Late Half-Long: 12–25 cm long conical and shouldered stump or pointed roots, medium to large foliage, productive; cultivars include 'Chantenay' (short), 'Royal Chantenay' (long), 'Danver', 'Autumn King', 'Berlicum', 'Imperator' (cross between 'Chantenay' and 'Nantes', United States, 1928); 'Kuroda' is a long Chantenay type bred in Japan around 1950, combining good internal colour with heat tolerance; local selections in Indonesia are also of the late half-long type, such as 'Cipanas', with cylindrical, smooth and dark orange carrots and strong foliage.

The cultivated carrot taxa cross readily with the wild carrot taxon (*D. carota* ssp. *carota*), which is very common in Europe and South-West Asia. It has to be rigorously removed from seed production fields to prevent white-rooted and prematurely bolting plants in a carrot field (white roots and annual habit are dominant over orange roots and biennial habit). There are several other wild carrot taxa and *Daucus* species occurring in the Mediterranean area and South-West Asia, most of which are crossable with the cultivated carrot.

Ecology In their adaptation to the northern latitudes of Europe, carrots became biennial and tolerant to long days (non-bolting) during the vegetative phase. They require subsequent vernalization at low temperatures to induce flowering. Carrots adapted to tropical and subtropical latitudes respond to long days by bolting even before the roots have properly thickened.

Carrots are mostly cultivated as a cool season crop. High soil temperatures, in excess of 25°C, induce slow growth rates, fibrous roots and low carotene content. For economic yields, carrots should be grown in tropical regions at altitudes above 700 m. Early-maturing carrot cultivars may grow in the lowlands, but yields will be low and roots will have a poor colour. Optimum air temperatures are 16–24°C. Soils should be well-drained, fertile and of a sandy texture. Heavy clay soils may induce malformed and twisted roots and harvesting will be difficult. Optimum pH is 6.0–6.5. A regular supply of water is essential to obtain smooth and even roots. Flowering and seed set are successful only in climates with mean day temperatures below 20°C.

Propagation and planting Seed multiplication at high latitudes with cold winters is based on stored and vernalized mature or young roots (stecklings) replanted in the field in spring (the root-seed method). In areas with mild winters and early snow cover, seeds are sown in late summer and the plants are left to overwinter in the field. These will bolt in spring and the seed-seed cycle is completed in 12–13 months. Carrot cultivars adapted to tropical regions have low vernalization requirements and are propagated in highland regions above 1200 m. Highland carrot growers often maintain their cultivars by selecting the best mature roots and replanting them at one end of the field. Bolting and seed set soon follow.

Seeds are sown, often mixed with sand, 1–2 cm deep in drills 10–15 cm apart in finely prepared soils previously cultivated to a depth of at least 30 cm. Seedlings are thinned to 5–8 cm in the rows. Seed requirements (200 plants/m^2 and 70% germination) for the dominant half-long carrot cultivars used in Asia, are 4–5 kg/ha. For bigger carrots, the density may be reduced to about 100 plants/m^2.

Husbandry Crop rotation is essential to reduce soilborne diseases and pests. Mulching (rice straw) after sowing is recommended to encourage germination. Seedlings may be earthed-up when roots start swelling to keep them cool and prevent green tops. In hot weather, light overhead shade is beneficial. Irrigation during dry spells is necessary to prevent irregular root development.

Nutrient requirements of carrots are particularly high for K (200–300 kg/ha), low to medium for N (100–150 kg/ha), normal for P, Ca, Mg and other elements. Carrots are sensitive to high Cl concentrations and more susceptible to diseases at very high soil pH. Liming or the use of Ca-containing fertilizers is recommended when pH is below 5.5. Well-decomposed organic manures are beneficial when applied moderately (10–20 t/ha). Fresh organic matter, e.g. from a leguminous crop, can be detrimental to the carrot crop.

Diseases and pests The major problems in tropical carrot production are leaf blights/spots (*Alternaria dauci* and *Cercospora carotae*) and root-knot nematodes (*Meloidogyne hapla*). Local Indonesian cultivars (e.g. 'Cipanas') have strong foliage with a remarkable field tolerance to *Alternaria* leaf blight, which often completely destroys the foliage of cultivars introduced from Europe. Crop loss by root-knot nematodes may be kept under control by crop rotation, e.g. with cereals, and by the application of organic manure.

Other diseases are powdery mildew (*Erysiphe polygoni* and *E. heraclei*), white rust (*Albugo candida*), bacterial blight (*Xanthomonas carotae*), black spot on roots (*Alternaria radicina*), and purple root rot (*Helicobasidium brebisonii*). Various root rots occur before or during storage, often after mechanical damage or as secondary pathogens (*Botrytis cinerea*, *Fusarium* spp., *Sclerotinia sclerotiorum*, *Pythium violae* and other spp., *Erwinia carotovora*). Root diseases are more severe in heavy soils with a poor structure. A total of 14 virus diseases have been identified in carrots, the most important being red leaf. Aster yellows is a mycoplasma.

The most noxious pest of carrot in temperate areas is carrot root fly (*Psila rosae*) to which some degree of resistance has been found in the Nantes-type cultivar 'Sitan' and in the wild species *D. capillifolius* Gilli. This pest has not been observed in South-East Asia. The lygus bug (*Lygus hesperus* and *L. elisus*) on seed crops, aphids (e.g. *Cavariella aegopidii*) as vectors of virus diseases, the leafhopper (*Macrosteles fascifrons*) as vector of aster yellows, carrot weevil (*Listronatus oregoneuses*) and other foliage pests have all been reported in carrot, but probably the only pest which may cause serious crop losses in South-East Asia is army worm (*Spodoptera* spp.).

Harvesting Carrot is mostly harvested manually by pulling up the roots at the leaves. This requires strong and healthy foliage. Mechanical harvesting (in Europe, United States) is also based on pulling up by the foliage, or first topping the leaves and then lifting the carrots as in potato harvesting. In Asia carrots are usually ready for harvesting 70–85 days after sowing. Mature roots should be orange-coloured internally down to the blunt tip.

Yield In Asia yields vary from 8–20 t/ha; higher yields are possible above 800 m altitude. In Europe and the United States 30–120 t/ha can be reached, depending on the type of cultivar and culture. Marketable yield is much influenced by plant density and time of harvest. Root weight and uniformity are closely related to seed size and quality.
Seed yields are 200–500 kg/ha.

Handling after harvest Carrots bunched with leaves will store up to 3 weeks in a cool place, but can remain in good condition for 100–150 days when topped (foliage removed) and stored at 1–4°C with 95–100% relative humidity. Carrots should be stored separately from other vegetables to prevent a bitter flavour induced by ethylene. Generally carrots store better when the dry matter content is high, when they are grown on soils with low organic matter content, when they are mature and harvested under moist conditions, and undamaged and free of diseases and pests. Carrots may be graded according to weight A (< 50 g), B (50–200 g), C (200–400 g) and D (> 400 g).

Genetic resources The genetic basis of modern orange carrot cultivars is rather narrow, considering that they are all derived from a few 18th Century Dutch cultivars. Exploitation of the genetic variation existing in wild *Daucus* L. germplasm in the Mediterranean and South-West Asian regions started only recently. Small working collections of *D. carota* and related species are available in Europe (United Kingdom, France, the Netherlands), United States and Japan.

Breeding Before 1960 breeding methods were based on mass selection in open-pollinated populations, but F_1 hybrids with greater uniformity are now increasingly replacing the older cultivars, particularly in Europe, the United States and Japan. Seed production of F_1 hybrid cultivars is based on cytoplasmic male sterility (cms) of one of the parent inbred lines. Two types of cms are used: (1) the brown anther type, in which the anthers degenerate before anthesis, based on S-cytoplasm and at least two recessive genes with complementary action, and (2) the petaloid type, in which the anthers are replaced by five additional petals, based on S-cytoplasm and at least two dominant genes with complementary action. The development and maintenance of inbred lines are complicated by severe loss of plant vigour after a few generations of inbreeding.
Main breeding objectives are improvements in total yield, growth rate and earliness, uniformity of root size and shape (cylindrical), dark orange external and internal colour (uniform in xylem and phloem), smooth periderm, resistance to cracking and breaking of the root during harvesting and post-harvest handling, flavour, texture, carotene content, strong foliage, non-bolting, resistance to diseases and pests. The most popular cultivars are somewhat conical, as these break less easily during harvesting.

Prospects Carrot will continue to be an important vegetable worldwide, but adaptation to hot climates will remain limited. Resistance to important diseases and pests is becoming an increasingly important aspect of carrot breeding.

Literature |**1**| Banga, O., 1963. Main types of western carotene carrot and their origin. Tjeenk Willink, Zwolle, the Netherlands. 153 pp. |**2**| Banga, O. & de Bruyn, J.W., 1968. Effect of temperature on the balance between protein synthesis and carotenogenesis in the roots of carrots. Euphytica 17: 168–172. |**3**| Heywood, V.H., 1983. Relationships and evolution in the Daucus carota complex. Israel Journal of Botany 32: 51–65. |**4**| Peterson, C.E. & Simon, P.W., 1986. Carrot breeding. In: Bassett, M.J. (Editor): Breeding vegetable crops. Avi Publishing Company, Westport, Connecticut, United States. pp. 321–356. |**5**| Quagliotti, L., 1967. Effects of different temperatures on stalk development, flowering habit and sex expression in the carrot. Euphytica 16: 83–103. |**6**| Shinohara, S. (Editor), 1984. Vegetable seed production technology of Japan. Shinohara's Authorized Agricultural Consulting Engineer Office, Tokyo, Japan. Vol. 1. 432 pp. |**7**| Schoneveld, J.A. (Editor), 1991. Teelt van peen [The cultivation of carrot]. PAGV series No 36, Proefstation voor de Akkerbouw en de Groenteteelt in de Vollegrond (PAGV), Lelystad, the Netherlands. 151 pp.

H.A.M. van der Vossen & E.N. Sambas

Emilia sonchifolia (L.) DC.

Contrib. bot. Ind.: 24 (1834).
COMPOSITAE
$2n = 10$

Synonyms *Cacalia sonchifolia* L. (1753), *Senecio sonchifolius* (L.) Moench (1802), *Emilia sonchifolia* (L.) DC. var. *javanica* (Burm.) Mattfeld (1928).

Vernacular names Emilia, Cupid's shaving brush, sow thistle (En). Emilie (Fr). Indonesia: patah kemudi, kemendilan (Javanese), jonge (Sundanese). Malaysia: ketumbit jantan, setumbak merah. Philippines: tagulinau (Tagalog), lamlampaka (Ilocano), pisowa-pisowa (Bisaya). Cambodia: smau reang tük. Thailand: hangplachon (central), phakdaeng (central), phakbang (northern). Vietnam: rau m[as] ti[as], rau chua l[ef], h[oof]ng b[oos]i th[ar]o.

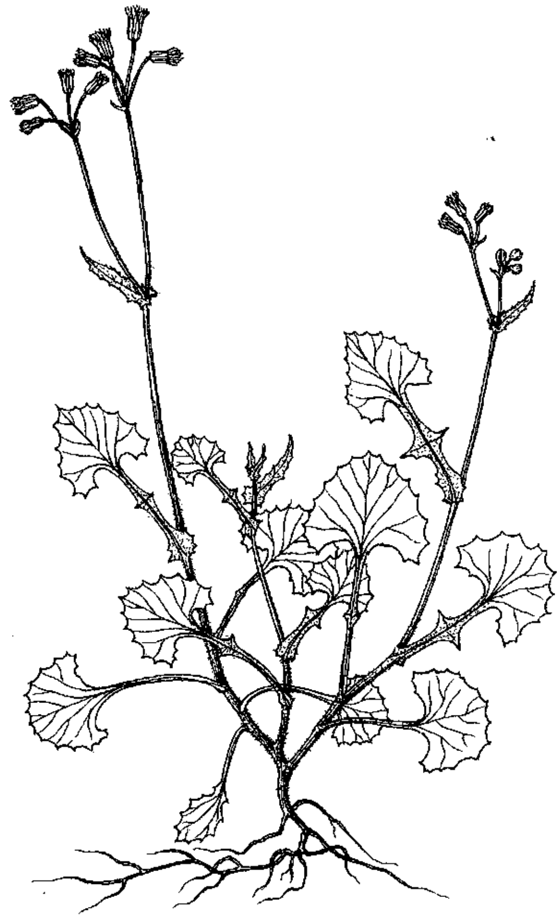
Origin and geographic distribution *E. sonchifolia* is a common weed with pantropical distribution. Its origin is unknown, but the genus *Emilia* Cassini is chiefly African. *E. sonchifolia* occurs wild throughout the Old World, including South-East Asia. In America it has been introduced and become naturalized.

Uses The use of emilia as a vegetable is reported from the whole of South-East Asia (with the exception of Papua New Guinea), and also from some other parts of the world (West Africa). The young, non-flowering plants are eaten raw or steamed as a side dish with rice. The older leaves or plants are cooked. Emilia is a slightly bitter-tasting green. The plant has many medicinal applications. It is administered internally against fever, coughs and diarrhoea, as well as externally as a poultice for sores and swellings, drops for dim eyes and sore ears.

Production and international trade Emilia plants are principally gathered from wild or spontaneous populations. It is sometimes cultivated on a small scale. Production statistics are not available, but it is occasionally offered for sale on local markets.

Properties Information on the nutritive composition is scarce. The leaves (West African sample) contain per 100 g edible portion: water 90 g, protein 2.2 g, fat 0.3 g, carbohydrates 5.3 g, fibre 1.1 g, ash 1.1 g. The energy value is 137 kJ/100 g.

Botany Annual herb, erect or at base prostrate, 10–150 cm tall, often branched from the very base, usually purplish-green, deeply rooting. Stem slender, striate, 2–3 mm in diameter, glabrous or nearly so, solid and not laticiferous. Leaves 4–16 cm × 1–8 cm, alternate, sessile, above dark green, beneath lighter green or tinged with purple, glabrous or nearly so, irregularly more or less coarsely dentate; lower leaves more or less deeply pinnatifid or lyrate, with an orbicular-ovate or subtriangular terminal lobe, lower part often narrowly alate, in juvenile plants often with patent white hairs; upper leaves linear or sagittate, semi-amplexicaul. Inflorescence a terminal head, few together in slender corymbs or rarely solitary; head 20–45-flowered, subcylindrical, 8–17 mm × 4–5 mm; peduncle filiform, 1–5 cm long; involucral bracts 7–10, narrowly oblong-ovoid, usually slightly shorter than the flowers, at first erect and cohering up to near the tips, later free and reflexed, green with narrow transparent margins; hypanthium at anthesis cupular, gradually turning convex; ray flowers absent; disk flowers bisexual; corolla



Emilia sonchifolia (L.) DC. – flowering and fruiting plant.

tubular, 5-lobed, 8–12 mm long, light red, rarely green or white; ovary short-hairy with 2 style arms; stamens connate, anthers 2–2.5 mm long with a small apical valve. Fruit an achene, linear-oblongoid, 2.5–3 mm long, ribbed, pilose, brownish; pappus hairs numerous, 6–9 mm long, white.
E. sonchifolia flowers year-round. Vegetatively it resembles species of *Sonchus* L., but it can easily be distinguished by its solid stems which do not contain milky sap. The genus *Emilia* is closely related to the genus *Senecio* L., the main difference being that in *Senecio* the involucre usually has a few, much shorter bracts (in *Emilia* all bracts are of equal length).

Ecology *E. sonchifolia* occurs frequently as a weed in compounds, roadsides, grassy fields, on dikelets along rice fields, in cropped fields, tea, rubber and other plantations, teak forest, and on beaches. It prefers sunny or slightly shaded, not too dry localities from sea-level up to 3000 m altitude. It is locally abundant, but always occurs scattered.

Agronomy Although *E. sonchifolia* is a very common weed of field crops, it is not considered very noxious or harmful. Propagation is by seed, and natural dispersal is by wind which easily carries the fruits over great distances.

Genetic resources and breeding No attention has been given to this species in germplasm collection and breeding.

Prospects According to older literature sources, *E. sonchifolia* is a much relished leafy vegetable. Developments in the horticultural sector have diminished the importance of gathered products like emilia. The natural abundance of *E. sonchifolia* has not led, and probably will not lead in the near future, to efforts to promote its cultivation.

Literature |**1**| Busson, F., 1965. Plantes alimentaires de l'Ouest africain [Food plants of West Africa]. Ministère de la Coopération, Paris, France. pp. 421, 424–425. |**2**| Koster, J.T., 1980. The Compositae of New Guinea 7. Blumea 26: 233–243. |**3**| Lugod, G.C., 1967. Wild plants used as vegetables. In: Knott, J.E. & Deanon Jr, J.R. (Editors): Vegetable production in South-East Asia. University of the Philippines Press, Los Baños, the Philippines. pp. 342–347. |**4**| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 129–130. |**5**| Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G., 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. pp. 80–81.

D. Sasmitamihardja

Enydra fluctuans Loureiro

Fl. Cochinch.: 511 (1790).
COMPOSITAE
$2n = 22$

Synonyms *Enydra longifolia* (Blume) DC. (1836), *E. paludosa* (Reinw.) DC. (1836).

Vernacular names Buffalo spinach (En). Indonesia: godobos (West Java), kokoha (West Java), ambur (Sumatra). Malaysia: chengkeru, kangkong kerbau. Philippines: kangkong kalabaw. Cambodia: kanting ring. Laos: bungz ping. Thailand: phakbung-ruam (central), phakbung-pling (northern), phakpaeng (northern). Vietnam: rau ng[oor] tr[aa]u, rau ng[oor] th[ow]m.

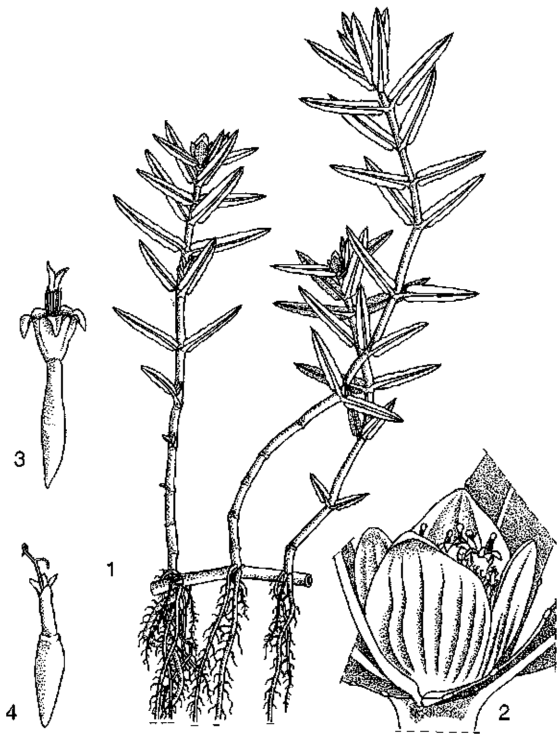
Origin and geographic distribution *Enydra fluctuans* is an old world species, possibly of Indo-Chinese origin, occurring in tropical Asia and Africa. It is common in all countries of South-East Asia, wild and sometimes cultivated.

Uses All green parts, young shoots in particular, are used in South-East Asia (particularly in Indo-China and Thailand) as a vegetable or condiment, both raw and steamed. It is somewhat bitter and laxative, which probably relates to its reputed medicinal properties. In the Philippines the crushed leaves have been reported to be applied to herpetic skin eruptions. As some of the vernacular names suggest, it is considered a good forage as well.

Production and international trade No production statistics are available, and buffalo spinach is only locally traded.

Properties Per 100 g edible portion, buffalo spinach contains: water 92.2 g, protein 1.5 g, fat 0.3 g, carbohydrates 3.8 g, fibre 1.3 g, ash 0.9 g. The energy value is 100 kJ/100 g.

Botany Perennial, often gregarious, erect-prostrate or free-floating, aromatic herb, 30–100 cm long. Stem cylindrical, 0.5–1 cm in diameter, hollow, hairy, sparsely branched, rooting at the nodes. Leaves opposite, (sub)sessile, narrowly oblong, 2–10 cm × 0.5–2 cm, base broadly truncate or subcordate, apex narrowly obtuse, margins usually dentate-serrate, finely gland-dotted on both surfaces. Inflorescence a globular head, up to 1 cm in diameter, sessile, solitary, terminal or pseudo-axillary (due to the development of axillary branches), heterogamous, many-flowered; involucre of 4 foliaceous, longitudinally-veined bracts, longer than the flowering heads and completely enclosing them. Ray flowers in many whorls, female; corolla with long tube and 2–5-lobed limb, white or greenish-white; ovary covered by palea



Enydra fluctuans Loureiro – 1, habit; 2, flower head; 3, ray flower without palea; 4, disk flower without palea.

which is ciliate at top, style ultimately exserted. Disk flowers more or less numerous, bisexual or sometimes sterile; corolla campanulate with 5-lobed rim; ovary as in ray flower, style arms 2; stamens connate, anthers ultimately exserted. Fruit an achene, oblongoid, 3 mm long, glabrous, closely clasped by the thickened palea (acting as floater), blackish, without a pappus.
Little is known about growth and development. In Java it is reported to flower year-round, in Vietnam from June to September. The fruits often do not develop.
The genus name *Enydra* Loureiro is often erroneously corrected to *Enhydra*.

Ecology Buffalo spinach is a herb of sunny, swampy localities. It occurs in and along ditches, water courses, margins of fish ponds and rice fields, from sea-level up to 1800 m altitude. In Java, it is more abundant above 500 m. Growing gregariously, it may sometimes clog water courses. It multiplies easily through dispersal of plant fragments, including fruits, by means of flowing water.

Agronomy Buffalo spinach is often cultivated on a small scale along streams and fish ponds. It is propagated vegetatively by cuttings. Pieces of stem with 3–4 nodes are inserted horizontally or at an angle into wet ground with 2–3 nodes covered by soil. Germination of seed is usually erratic.

Genetic resources and breeding Neither germplasm collections nor breeding programmes are known for this species.

Prospects As a weed, *E. fluctuans* is considered of minor agricultural importance. More information is needed on its occurrence as a weed and its use as a crop plant in the various parts of South-East Asia.

Literature |1| Backer, C.A. & Bakhuizen van den Brink Jr, R.C., 1965. Flora of Java. Wolters-Noordhoff, Groningen, the Netherlands. Volume 2. pp. 401–402. |2| Lack, H.W., 1980. The genus Enydra (Asteraceae, Heliantheae) in west tropical Africa. Willdenowia 10: 3–12. |3| Petelot, A., 1953. Les plantes médicinales du Cambodge, du Laos et du Vietnam [Medicinal plants of Cambodia, Laos and Vietnam]. Vol. 2. Archives des Recherches Agronomiques et Pastorales au Vietnam No 18: 53. |4| Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G., 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. pp. 82–83. |5| Vo Van Chi, 1989. Cây rau làm thuôc [Medicinal vegetables]. NXB Tong hop Dong Thap. pp. 222–223.

Nguyen Tien Ban

Erechtites Rafin.

Fl. Ludovic.: 65 (1817).
COMPOSITAE
$x = 10$; $2n = 40$ (both species).

Major species and synonyms
- *Erechtites hieracifolia* (L.) Rafin. ex DC., Prodromus 6: 294 (1838), synonym: *Senecio hieracifolius* L. (1753).
- *Erechtites valerianaefolia* (Wolf) DC., Prodromus 6: 294 (1838), synonym: *Senecio valerianaefolius* Wolf (1825).

Vernacular names Pilewort, Malayan groundsel (En). Fireweed (Am). Indonesia: sintrong (Sunda), bolostrok (Sunda), jambrong (Sunda). Philippines: hagalpohansaw (Bisaya), doyan-doyan (Bukidnon), salimbego (Marinduque). Thailand: phakkat-nokkut (central).

Origin and geographic distribution
- *E. hieracifolia* is native to the more humid parts of North and South America. It is adventitious

in Central Europe, Hawaii and South-East Asia. It does not occur in Africa, the Near East, Australia or the Pacific islands.
- *E. valerianaefolia* is native to tropical and subtropical America and adventitious in many other tropical areas including South-East Asia, southern China, Australia and the Pacific islands, but does not occur in Africa.

Uses The young tops of pilewort, including young flower heads, are much relished in Java as a vegetable, mostly eaten raw with rice and a sauce of ground hot capsicum peppers. They can also be consumed after being steamed, but this method is rarely encountered because the cooking makes the leaves very soft. It is believed that consumption of pilewort improves the milk production of women after childbirth. In the New World, *E. hieracifolia* is only used medicinally to dispel fever and as a cough remedy. In the United States, it was formerly given as an emetic, alterative, cathartic and acrid tonic and used as an astringent. Pilewort is cut in Indonesia as fodder for small ruminants, and is considered a good cattle feed in Australia.

Production and international trade Leaves of pilewort are sold locally and are occasionally found in West Javanese markets. Tops are harvested directly from the wild and there are no records of cultivation.

Properties No data on the nutritive value are available. Related to the medicinal properties, *E. hieracifolia* contains several alkaloids, two of which have been identified as seneciphylline and senecionine.

Description Erect annual or perennial herbs, succulent, up to 2 m tall. Stems ribbed, simple or much branched in upper half, fleshy, variously pubescent. Leaves alternate, sessile or petiolate, very variable in size, form, hairiness and degree of incision. Inflorescences are heads, campanulate-cylindrical, heterogamous, arranged in terminal corymbs; involucre uniseriate, cylindrical, consisting of a whorl of lanceolate, acute bracts at first coherent and erect, finally separating and reflexed, with dark-coloured central band, and a few lower bracts, much smaller, free; receptacle flat or cup-shaped, naked; ligulate flowers absent; marginal flowers (florets) 1–many seriate, female, with filiform, 3–5-dentate corolla; central flowers (disk florets) numerous, bisexual, with tubular-filiform corolla ending in funnel-shaped, 4–5-dentate limb; style-arms long, with crown of divergent hairs surrounding appendage of fused papillose hairs. Fruits linear achenes, ribbed; pappus hairs numerous, thin, dentate.

Erechtites hieracifolia (L.) Rafin. ex DC. – flowering and fruiting shoot.

- *E. hieracifolia.* Annual herb, up to 2 m tall. Leaves sessile, or if shortly petiolate, then petiole conspicuously alate, lanceolate or oblong-lanceolate, 3–30 cm × 0.5–7 cm, lower ones with a narrowed, higher ones with a broad, truncate or auricled base; higher ones coarsely dentate-pinnately lobed. Peduncle up to 6 cm long; flower head 12–15 mm × 6–8 mm, diameter always about half its length; involucre 10–12 mm long; flowers light yellow; marginal florets bi- or pluriseriate; achenes ca. 2.5 mm long, brown, with entirely white, 8–12 mm long pappus.
- *E. valerianaefolia.* Annual herb, up to 2 m tall. Leaves petiolate or inconspicuously alate at base; petiole 0.5–4 cm long; leaf-blade oblong, pinnately lobed to pinnatipartite, 4–18 cm × 2–9 cm. Peduncle up to 5 cm long; flower head 10–15 mm × 3–5 mm, diameter always less than one-third of its length; involucre 8–10 mm long; flowers light violet; marginal florets uniseriate or subbiseriate; achenes ca. 3 mm long, brown, with reddish, 8–10 mm long pappus.

Growth and development Both species are found on recently disturbed areas in forest zones, and also as weeds in crops. They grow in abundance due to their easy establishment and the production of a large number of viable seeds which are easily dispersed by wind. They flower and fruit year-round.

Other botanical information Three varieties are distinguished within *E. hieracifolia*, mainly on the basis of the length of the bracts on the peduncle and of the free bracts of the involucre. According to this, all South-East Asian plants belong to var. *cacalioides* (Fischer ex Sprengel) Grisebach with bracts on the peduncle as long as the involucre and the free bracts longer than 1/4 of the length of the involucre; those bracts are also ciliolate with multicellular hairs.

The reputation of *E. hieracifolia* as a pantropical weed rests largely on confusion with *Crassocephalum crepidioides* (Benth.) S. Moore. *C. crepidioides* has longer style-arm appendages, dark red achenes, lyrately pinnatifid and petiolate lower leaves, usually lacking pistillate marginal florets, and florets often pink. It is native to Africa.

E. valerianaefolia is sometimes subdivided into four botanical forms based on foliage differences, but intermediate forms occur, so this subdivision is difficult in practice.

E. hieracifolia and *E. valerianaefolia* are often confused. The major differences are: pappus white in *E. hieracifolia*, reddish in *E. valerianaefolia*; leaves sessile versus petiolate; diameter flower head about 1/2 its length versus less than 1/3 its length; marginal florets bi- or pluriseriate versus uni- or sub-biseriate. In tropical America the species sometimes hybridize. In West Java the two species are not clearly discriminated by their vernacular names.

Ecology Both *Erechtites* species thrive in sunny, rather moist localities, on roadsides, in recent clearings and on waste sites, often becoming common but tolerable weeds in estate crop plantations. They are among the early colonizers in newly cleared areas, especially after burning (fireweed). They occur in the lowlands as well as in the mountains up to 2200 m altitude. Their presence in quantity is usually considered an indication of a very fertile topsoil.

Agronomy Pileworts are not cultivated. As companion weeds of crops, they are always readily available. They are often spared during selective weeding.

Genetic resources and breeding No germplasm collections of pileworts are available.

Prospects Pilewort is considered as a weed in all areas where it occurs, and activities are directed more towards its eradication than towards its propagation. It is worthwhile investigating its nutritional value and promoting its use as a vegetable.

Literature |1| Backer, C.A. & van Slooten, D.F., 1924. Geïllustreerd handboek der Javaansche theeonkruiden en hunne betekenis voor de cultuur [Illustrated handbook of weeds of Javanese tea plantations and their significance for tea-growing]. Ruygrok, Batavia, Dutch East Indies. Figs. 232 & 233. |2| Belcher, R.O., 1956. A revision of the genus Erechtites (Compositae) with inquiries into Senecio and Arrhenechthites. Annals of the Missouri Botanical Garden 43: 1–85. |3| Morton, J.F., 1981. Atlas of medicinal plants of Middle America (Bahamas to Yucatan). C.C. Thomas Publisher, Springfield, Illinois, United States. pp. 927–928. |4| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 132–134. |5| Wee, Y.C., 1970. Weed succession observations on arable peat land. The Malayan Forester 33: 63–69.

M.A. Rifai

Hibiscus acetosella Welwitsch ex Hiern

Cat. Afr. Pl. Welwitsch 1(1): 73 (1896).

MALVACEAE

$2n = 4x = 72$

Synonyms *Hibiscus eetveldianus* De Wild. & Th. Durand (1899).

Vernacular names False roselle, red-leaved hibiscus, bronze hibiscus (En). Fausse oseille de Guinée (Fr). Indonesia: gamet.

Origin and geographic distribution False roselle is of African origin and was possibly domesticated in Angola or Zaire. It is only known as a cultivated plant. It is well-distributed throughout tropical Africa and must have been introduced as a vegetable or as an ornamental plant into South-East Asia, occasionally found wild.

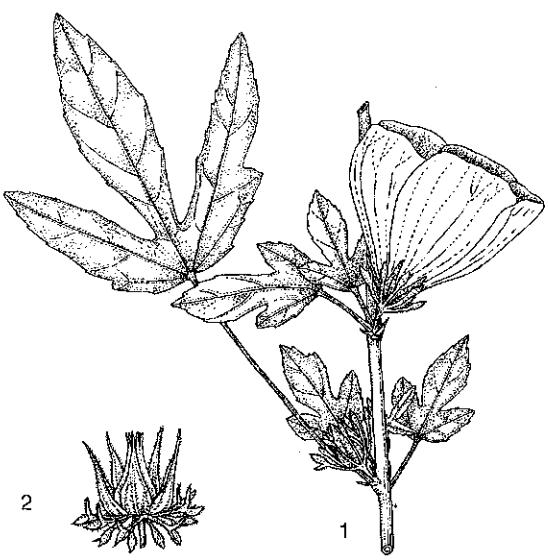
Uses The leaves and young shoots are eaten as a side-dish with rice. They are sour in taste and slightly mucilaginous, and for this reason are added in small quantities to numerous dishes. False roselle is sometimes grown as a colourful temporary hedge. The stem yields a fibre of good quality, but seemingly not in profitable quantity.

The red forms are popular ornamentals, also grown as frost-tender annuals in cool-temperate regions.

Production and international trade False roselle is mainly produced in home gardens for domestic consumption.

Botany Annual or short-lived perennial herb or shrub, 0.5–2.5 m tall, little-branched, unarmed, usually entirely red or with a marked red flush. Leaves alternate, slightly fleshy, glabrous; petiole dark red, 0.5–10 cm long; leaf-blades broadly orbicular-ovate in outline, 2–12 cm × 2–12 cm, the lower ones deeply palmately 3–5-parted or lobed, the upper ones undivided and rhomboid, at base 5–7-nerved, margins irregularly serrate-crenate, above bronze-green to red, beneath usually red with a distinct nectary at the base of the midrib. Flowers solitary, axillary; pedicel up to 1 cm long; epicalyx segments 8–10, narrowly spathulate, 1–2 cm long, spreading, with an erect, linear, 3–4 mm long appendage, with scattered stiff hairs; calyx campanulate, regularly 5-cleft, 1.5–2 cm long, each lobe outside stiff-hairy on the nerves and on the centre of the midrib, with an oblong nectary, after flowering closely enveloping the capsule, accrescent to 2.5 cm; corolla wine-red with a dark purple centre, 3–7.5 cm in diameter; petals 5, obliquely obovate, 2–4 cm × 1.5–3.5 cm, apex rounded, base fleshy and narrowed, glabrous, above the dark red basal spot with distinct radiating veins; staminal column erect, 1–2 cm long, dark red, throughout its length beset with brown, shortly stalked anthers; style arms 5, 3–5 mm long, hardly exserted from the staminal tube, each ending in a discoid, dark red long-hairy stigma. Fruit an ovoid capsule, 1–2.5 cm × 1–1.5 cm, very acute, densely tuberculate, hispid, red, many-seeded. Seed reniform to globular, 3–5 mm in diameter, dark brown when ripe, verruculose. The flower structure favours self-pollination, but some outcrossing by insects may occur. Cultivar 'Red Shield' has brilliant maroon leaves.

H. acetosella ($2n = 72$) is most probably an allotetraploid derived from *H. asper* Hook.f. ($2n = 36$) and *H. surattensis* L. ($2n = 36$). *H. asper* is a wild plant from tropical Africa, sometimes cultivated for its fibres. *H. surattensis* is a wild plant of tropical Africa and Asia, also cultivated for its edible young leaves and for its fibres (see chapter on Minor Vegetables).



Hibiscus acetosella Welwitsch ex Hiern – 1, flowering shoot; 2, fruit.

Ecology False roselle is generally encountered in home gardens, but also as an escape in waste places and on roadsides. Because of insufficient care, it usually remains small, sometimes hardly 15 cm tall. It grows on all kinds of soils, but requires good drainage. In Java (6–8°S) year-round flowering has been reported as well as seasonal flowering (plants remaining vegetative under the long-day conditions of December to March).

Agronomy False roselle is propagated by seed, but multiplication is also possible by means of stem cuttings. Because of the scarcity of commercial plantings, little is known about cultural requirements and practices. They are probably rather similar to those of roselle (*Hibiscus sabdariffa* L.). Soilborne diseases such as *Rhizoctonia solani* and *Sclerotium rolfsii* are reported to cause plant losses.

Genetic resources and breeding Germplasm is maintained at the International Jute Organization (IJO), Dhaka, Bangladesh. No selection work for vegetable use has ever been undertaken. *H. acetosella* has been the subject of in-vitro propagation studies. In tissue culture it is considered as relatively fast-growing. Plant regeneration through embryogenesis from callus gives good results.

Prospects False roselle will remain a common home garden vegetable. Because of similar uses as roselle, a comparative study of *H. acetosella* and *H. sabdariffa* L. would be very useful to determine other similarities and differences.

Literature |1| Lim-Ho Chee Len & Lee Sing Kong, 1988. In vitro propagation of some shrubs at the Singapore Botanic Gardens. Biotrop Special Publication 35: 197–207. |2| Reynolds, B.D. &

Blackman, W.J., 1983. Embryogenesis and plantlet regeneration from callus of Hibiscus acetosella. Journal of the American Society of Horticultural Science 108(2): 307–310. |3| Stevels, J.M.C., 1990. Légumes traditionnels du Cameroun, une étude agro-botanique [Traditional vegetables of Cameroun, an agro-botanic study]. Thesis. Wageningen Agricultural University Papers 90-1, Wageningen, the Netherlands. pp. 172–177. |4| van Borssum Waalkes, J., 1966. Malesian Malvaceae revised. Blumea 14(1): 59–60.

S.H. Widodo

Hibiscus sabdariffa L.

Sp. pl.: 695 (1753).
MALVACEAE
$2n = 4x = 72$

Synonyms *Hibiscus digitatus* Cav. (1787).

Vernacular names Roselle, red sorrel, Indian sorrel, Jamaican sorrel (En). Oseille de Guinée, roselle (Fr). Indonesia: gamet walanda (Sunda), kasturi roriha (Ternate). Malaysia: asam susur. Philippines: roselle (Tagalog), kubab (Ifugao), talingisag (Subanon). Cambodia: slök chuu. Laos: sômz ph'oox dii. Thailand: krachiap-daeng (central), krachiap-prieo (central), phakkengkheng (northern). Vietnam: b[uj]p gi[aas]m.

Origin and geographic distribution Although not known with certainty, *H. sabdariffa* is most probably of African origin, where it seems to have been domesticated originally for its seeds. The use of the leaves and the fleshy calyx developed much later and these vegetable types were introduced into America and India in the 17th Century. It was in Asia that types suitable for the production of fibres were selected. Roselle now has pantropical distribution, usually in cultivation, sometimes as an escape.

Uses Young shoots and leaves are used raw or cooked as vegetable. They have a sour taste and are slightly mucilaginous. The fleshy calyces are widely used in making beverages (roselle syrup, roselle wine), jams and jellies. The calyces can also be dried and stored for later use. In Egypt they are used to prepare the very popular acid roselle tea. In some parts of Africa the seeds are eaten roasted in the same way as sesame, and can be used as a source of edible oil. The bast fibre is a good substitute for jute; it is used for making cordage, rope and sacks, and also in the paper industry. Roselle also has medicinal applications. The calyces are diuretic and are believed to decrease blood cholesterol. The seeds are mildly laxative and diuretic.

Production and international trade Roselle is grown in many tropical countries primarily for its leaves and edible calyces. It is among the most important leafy vegetables in the drier parts of West Africa. In South-East Asia it is a typical home garden plant. As a fibre crop it is mainly important in South Asian countries (India, Bangladesh) and in China, and to a lesser extent in South-East Asia (Thailand, Indonesia). Roselle accounts for about 20% (700 000 t annually) of jute-like fibres.

Properties Per 100 g edible portion, the leaves contain: water 85 g, protein 3.3 g, fat 0.3 g, carbohydrates 9 g, fibre 1.6 g, Ca 213 mg, P 93 mg, Fe 4.8 mg, b-carotene 4.1 mg, vitamin B_1 0.17 mg, vitamin B_2 0.45 mg, niacin 1.2 mg, vitamin C 54 mg. The energy value is 180 kJ/100 g. The calyces are considerably lower in protein and vitamin contents; they contain about 4% citric acid. The seeds contain 17–20% of an edible oil, which is similar in properties to cotton-seed oil. Roselle fibre is coars-

Hibiscus sabdariffa L. – 1, flowering shoot; 2, flower; 3, capsule surrounded by fleshy calyx.

er and stiffer than jute fibre, but equal in strength. It is much stronger than kenaf fibre (*H. cannabinus* L.). The 1000-seed weight is 15–25 g.

Description Robust annual, erect, herb, up to 4 m tall, often with much anthocyanin in the green parts. Stem often woody at the base. Leaves simple, alternate, polymorphic, 8–15 cm × 6–14 cm, with a nectary on the midrib beneath; the lower leaves often undivided, ovate; the upper leaves palmately 3–5-parted with lanceolate segments; petiole 4–12 cm long. Flowers solitary, axillary and showy, yellow or pink with a dark purple basal spot; epicalyx segments 7–10, without an appendage, reddish, linear and usually fleshy; calyx 5-lobed, 1–2 cm long, with a nectary on the costae outside, usually becoming large and fleshy after anthesis, accrescent to 5 cm and closely enveloping the capsule, dark purple or red; corolla with 5 petals, not widely opened, pale yellow or pale pink with dark purple basal spot; staminal column erect, 1.5–2 cm long, bearing anthers almost from the base; style arms 5, short, each ending in a discoid stigma. Fruit an ovoid capsule, 2–2.5 cm × 1.5–2.5 cm, obtuse, pilose, many-seeded, dehiscent by 5 valves. Seed reniform, 4–7 mm long, blackish brown, pilose.

Growth and development The vegetative growth phase normally lasts 4–5 months, but flowering may start as early as 21/2 months or as late as 7–8 months after sowing. Roselle is a self-pollinated crop, but some cross-pollination by insects may occur. Fruit ripening takes 2–3 months from pollination.

Other botanical information The distinction between vegetable and fibre types is best expressed in a cultivar group classification:

- cv. group Sabdariffa (synonym: var. *sabdariffa*) consists of bushy, much-branched forms, up to 2 m tall, with a very fleshy calyx, lacking hairs and prickles, normally cultivated as a leafy vegetable or for the edible calyx;
- cv. group Altissima (synonym: var. *altissima* Wester) consists of tall, unbranched forms, up to 4 m tall, usually with inedible calyces, frequently beset with hairs and prickles, grown for their bast fibres.

H. sabdariffa ($2n = 72$) is most probably an allotetraploid derived from *H. asper* Hook.f. ($2n = 36$) and a second still unknown species with $2n = 36$.

Ecology *H. sabdariffa* is a short-day plant and is often used as a laboratory plant in the study of photoperiod sensitivity. It requires 12–12½ hours daylength for flowering and fruiting; in Java (6–8°S) usually no flowering is observed during the period December–March. The length of the vegetative period can thus be manipulated through the sowing date. Roselle tolerates a wide range of soil conditions, but for economic yields, soils should be well-supplied with organic material and essential nutrients. It is reasonably drought resistant.

Agronomy Roselle is usually grown from seed, but can also be propagated by stem cuttings. For commercial plantings seeds are sown in a nursery and transplanted when they are 4 weeks old and 10–12 cm high. In West Africa, roselle or 'dah' is usually broadcast at low densities in fields of the main food crops.

For calyx production, plants are relatively widely spaced (120 cm × 90 cm, or 10 000 plants/ha). The calyces must be picked about 15–20 days after flowering. Well-developed plants may yield up to 250 calyces, corresponding to 1–1.5 kg per plant. Crop yields vary from 5–15 t/ha. For leaf production, plants can be spaced closer, e.g. 60 cm × 100 cm. Leaves or young shoots can be harvested from the third month onwards. Yields up to 10 t/ha have been reported. When flowering interferes too much with vegetative development, harvesting of leafy shoots can be stopped in favour of a subsequent crop of calyces to be harvested 4–5 months after sowing.

When grown for fibre, roselle is planted at very close spacings of 12–20 cm × 12–20 cm with 1–2 plants per hill. Harvesting is done before the onset of flowering (delayed by long days) 4–5(–8) months after sowing. The harvested stems are retted in water for 5–14 days, then the bark is stripped and gently beaten to separate the fibres which are then washed and dried. Fibre yields are about 1.5–2.5 t/ha. Three quality groups of fibres are distinguished, based on length, colour, purity and stiffness. Seed yields of 200–1500 kg/ha have been reported.

Important diseases are leaf-spot (*Cercospora hibisci*) and foot rot (*Phytophthora parasitica*). Roselle has many pests in common with other malvaceous crops like cotton and okra. Common pests are cotton stainer bugs (*Dysdercus superstitiosus*), bollworms (*Earias biplaga, E. insulana*), flea beetles (*Podagrica* spp.) and nematodes.

Genetic resources and breeding Germplasm is maintained by the Australian Tropical Forages Genetic Resources Centre, CSIRO, Queensland, Australia, by the Jute Agricultural Research Institute, Barrackpore, West Bengal, India, and by the International Jute Organization (IJO), Dhaka, Bangladesh.

Selection and breeding work has been limited to types grown for fibre, and a few improved cultivars have been released. There seems to be some risk of genetic erosion in India and Bangladesh, but not in other parts of the world where the vegetable types predominate.

Prospects Roselle is an interesting green because of its good drought resistance. It offers a useful combination of edible vegetative and generative parts. The production of fibre will remain important, but high labour costs and competition from chemically fabricated substitutes may cause a shift towards its use in paper pulp production.

Literature |1| Boulanger, J., 1989. Kenaf und Roselle [Kenaf and roselle]. In: Rehm, S. (Editor): Handbuch der Landwirtschaft und Ernährung in den Entwicklungsländern. Bd. 4. Spezieller Pflanzenbau in den Tropen und Subtropen [Handbook of agriculture and nutrition in underdeveloped countries. Vol. 4. Special plant cultivation in the tropics and subtropics]. 2nd edition. Eugen Ulmer, Stuttgart, Germany. pp. 568–573. |2| Stevels, J.M.C., 1990. Légumes traditionnels du Cameroun, une étude agro-botanique [Traditional vegetables of Cameroun, an agro-botanic study]. Thesis. Wageningen Agricultural University Papers 90-1, Wageningen, the Netherlands. pp. 177–188. |3| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 332–337. |4| van Borssum Waalkes, J., 1966. Malesian Malvaceae revised. Blumea 14(1): 64–65. |5| Wilson, F.D. & Menzel, M.Y., 1964. Kenaf (Hibiscus cannabinus), roselle (Hibiscus sabdariffa). Economic Botany 18: 80–91.

T. Boonkerd, B. Na Songkhla & W. Thephuttee

Hydrocotyle sibthorpioides Lamk

Encycl. méth. bot. 3: 153 (1789).

UMBELLIFERAE

$2n$ = unknown

Synonyms *Hydrocotyle rotundifolia* DC. (1830), *H. benguetensis* Elmer (1909), *H. delicata* Elmer (1909).

Vernacular names Lawn pennywort (En). Indonesia: tikim (Jakarta), antanan leutik (West Java), andem (Java). Malaysia: ulam gunung, pegaga embun. Philippines: tomtomon (Bontoc), enit (Kalinga), kanapa (Igorot). Thailand: ya-klethoi (central). Vietnam: rau m[as] m[ow].

Origin and geographic distribution *H. sibthorpioides* is probably of Asiatic origin, but has become a weed with pantropical and subtropical distribution. It is very common all over South-East Asia.

Uses *H. sibthorpioides* is a green used raw or steamed with rice. The smell and taste are similar to parsley. In Indonesia it is a common ingredient of Sundanese 'rujak' (cut-up mixture of young fruits with a capsicum pepper sauce) and 'asinan' (fruits and vegetables in brine).

H. sibthorpioides has medicinal applications similar to *Centella asiatica* (L.) Urban (syn. *Hydrocotyle asiatica* L.), in particular against skin diseases and as cough remedy.

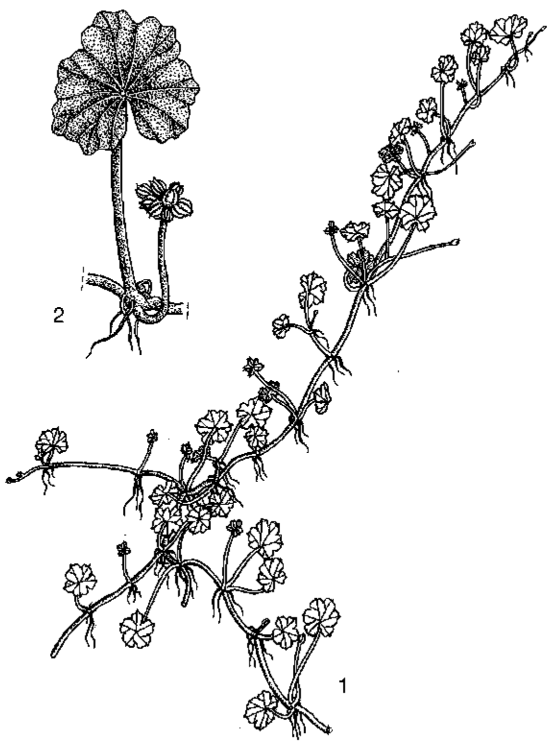
Due to its limited dimensions, it is an insignificant weed in agriculture, but can still be a nuisance in ornamental lawns. It is sometimes helpful in protecting topsoil against erosion.

Production and international trade *H. sibthorpioides* is marketed locally in small quantities and is never individually accounted for in production statistics.

Properties No information is available on the nutritive value. In view of its medicinal uses, considerable research on its chemical constituents is being done in Japan. Like most Umbelliferae, *H. sibthorpioides* contains essential oil, the major terpenoid component being trans-beta-farnesene. A lignan, L-sesamin, and a caffeoylgalactoside have also been isolated from the plant.

Botany Perennial, prostrate to suberect, polymorphous herb, up to 50 cm long, with slender, stoloniferous stems, rooting at the nodes. Leaves alternate; stipules ovate to obovate, up to 1 mm × 1.5 mm; petiole up to 6 cm long, not sheathing at base; leaf-blade roundish to 5-angular in outline, 0.3–2.5 cm across, deeply cordate, 3–5-lobed to 3–5-partite, glabrous or hairy; segments crenate to serrate. Inflorescence an umbel, 5–15-flowered, solitary, opposite the leaves; peduncle up to 3 cm long; involucral bracts 4–10, very small, around and between the flowers; flowers bisexual, subsessile; calyx teeth 5, minute or obsolete; petals 5, ovate, 0.7 mm × 0.5 mm, greenish-white; disk flat, margin elevated; stamens 5, alternate with the petals; ovary inferior; styles 2. Fruit a laterally compressed schizocarp, with 2 one-seeded mericarps; mericarp 1–1.3 mm × 0.8 mm, yellow to brown, glabrous or with short stiff hairs, sometimes red-punctulate.

H. sibthorpioides is very variable in the shape of the leaves, depth of incisions, and hairiness of all parts. Many forms have been described as separate species, but all kinds of intermediate forms occur. It cannot always be easily distinguished from the related species *H. javanica* Thunb. The



Hydrocotyle sibthorpioides Lamk – 1, flowering and fruiting shoot; 2, stem part with leaf and infructescence.

latter has larger leaves (3–8 cm across) and 15–50-flowered inflorescences. It is used – in combination with other ingredients – as a fish poison.

Ecology Lawn pennywort is commonly found in sunny or slightly shaded, moist localities, e.g. along stream banks, between stones in pathways, alongside walls, but also in meadows and in plantations of tree crops. It has a wide altitudinal adaptation, occurring from sea-level up to 4000 m. Natural dispersal is by water and animals.

Agronomy *H. sibthorpioides* can be easily propagated by means of rooted stem parts as well as by seeds. It is rarely planted specifically as a vegetable crop; more often shoots are picked from naturally occurring patches, for instance in fields of food crops such as cassava.

Genetic resources and breeding Neither germplasm collections nor breeding programmes exist.

Prospects *H. sibthorpioides* is a green which is well-appreciated by Indonesians, Malaysians and Chinese, but is mostly used in small quantities as a relish or condiment in various dishes. It might be interesting commercially if methods are developed to offer it in small quantities to the consumer, e.g. living plants in small pots as is done for parsley, leaf celery or chives in the western world.

In the future, *H. sibthorpioides* might assume more importance as a medicinal plant because of its promising chemical constituents.

Literature |1| Asakawa, Y, Matsuda, R. & Takemoto, T., 1982. Mono- and sesquiterpenoids from Hydrocotyle and Centella species. Phytochemistry 21(10): 2590–2592. |2| Buwalda, P., 1949. Umbelliferae. In: van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 4. Noordhoff-Kolff, Djakarta, Indonesia. pp. 113–141. |3| Soeparma Satiadiredja, 1950. De teelt en het gebruik van Indonesische groenten en toekruiden [The cultivation and use of Indonesian vegetables and condiments]. Wolters, Groningen, the Netherlands. pp. 50–51. |4| Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G., 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. pp. 50–51.

H. Sangat-Roemantyo

Ipomoea aquatica Forsskal

Fl. Aegypt.-Arab. 44 (1775).

CONVOLVULACEAE

$2n = 30$

Vernacular names Kangkong, water convolvulus, water spinach (En). Patate aquatique, liseron d'eau (Fr). Indonesia: kangkung, kankong. Malaysia: kangkong, kankung. Papua New Guinea: kangkong, kango. Philippines: kangkong (Tagalog), balangog, galatgat (Ilocano). Cambodia: trâkuön. Laos: bôngz. Thailand: phakbung (general), phakthotyot (central). Vietnam: rau mu[oos]ng.

Origin and geographic distribution Kangkong originated in tropical Asia (possibly India) and can be found in South and South-East Asia, tropical Africa, South and Central America and Oceania. Only in South and South-East Asia is kangkong an important leafy vegetable. It is intensively grown and frequently eaten throughout South-East Asia, Hong Kong, Taiwan and in southern China.

Uses The young tops or plants (stem and leaves) are cooked or lightly fried in oil and eaten in various dishes. The vines are used as fodder for cattle and pigs. In Malaysia it is widely grown in fish ponds by the Chinese who feed it to their pigs.

Production and international trade Production figures are difficult to obtain due to the lack of any registration of information on production and trade. In Thailand and Malaysia white-flowering kangkong is the second most widely grown leafy vegetable after pak choi (*Brassica rapa* L. cv. group Pak Choi). Red kangkong is collected from the wild and consumed in rural areas of Malaysia, but in Thailand and Singapore it is sometimes sold in the markets as well. In Indonesia the harvested area is estimated at 10 000 ha (1988), mainly of paddy-field kangkong, planted by stem cuttings and harvested by monthly ratooning during nine months of the year. In Malaysia the area under cultivation is estimated to be 600–1100 ha with a total production of 60 000–220 000 t/year. Marketing in Thailand, Malaysia and Singapore is usually done by middlemen. Kangkong is exported from Bangkok to Hong Kong and to a lesser extent to European countries.

Kangkong seed is produced on a commercial scale in Hong Kong, China, Taiwan, Thailand, the Philippines and Japan. In Malaysia 20% of kangkong farmers grow their own seed. Thailand is the leading seed producer of the region with 700–900 t per year, of which about 500 t is exported to neighbouring countries. The bulk of the seed is still landrace Phakbung-chin produced by paddy farmers in Nakhon Pathom Province as an additional cash crop. The seed trade in Malaysia and Singapore is not well organized. Chinese middlemen import seed from Thailand and Taiwan. Malaysia imports about 180 t of seed annually.

Properties Unfortunately, most sources do not state whether only leaves or stems and leaves were analysed. The higher the ratio of leaf-blades to petioles and stems, the higher the nutritional value. Mean values per 100 g edible portion are: water 90.2 g, protein 3.0 g, fat 0.3 g, carbohydrates 5.0 g, fibre 1.0 g, ash 1.6 g, Ca 81 mg, Mg 52 mg, Fe 3.3 mg, provitamin A 4000–10 000 IU, vitamin C 30–130 mg. The energy value is 134 kJ/100 g. The 1000-seed weight is ca. 40 g.

Description Annual or perennial, fast-growing herb with smooth, succulent, hollow stems rooting at the nodes in wet ground. Leaves alternate, long-petioled, triangular or lanceolate, 2.5–15 cm × 0.5–10 cm, heart-shaped or hastate at the base; petioles green or purple. Flowers borne singly or in clusters of 2–7 in the leaf axils, funnel-form, 4–7.5 cm long with a limb about 5 cm wide, with a magenta or purple throat, or pink, lavender or purple. Fruit an ovoid capsule, 7–9 mm in diameter, smooth, brown, cupped by the 5-lobed calyx, containing 2–4 seeds. Seed angular to rounded, smooth or velvet, 4 mm long, black or light to dark brown. Seedling exhibits epigeal germination, with horseshoe-shaped cotyledons.

Ipomoea aquatica Forsskal – flowering shoot.

Growth and development Germination rates of kangkong are usually low (< 60%) and vary with the colour of the seed-coat, being highest in the black-seeded types. The hard-seededness may be influenced by the length of time between cutting the plants and threshing. There is also evidence that emergence behaviour has a strong genetic component. Plants start developing lateral branches from cotyledonary buds 2–3 weeks after sowing. Thereafter the main axis and both laterals each produce about one leaf every 2–3 days. Harvesting may start 20–30(–50) days after sowing. Flowering is required only for seed production, and under conducive conditions may start 48–63 days after sowing.

Other botanical information *Ipomoea reptans* Poiret (1814) is an incorrect synonym which is often used.

Two types of kangkong are distinguished in South-East Asia:

- Red kangkong: plants with green/purple stems, dark green leaves with sometimes purple petioles and veins, and light purple to white flowers. Plants of this group can be found growing wild

in tropical South-East Asia (Indonesia and Malaysia: kangkung air; Thailand: phakbung-thai). Flowering and seed set do not always occur. In Thailand and Malaysia, red kangkong is gathered by the local population for food and as animal feed.
- White-flowering kangkong: plants with green/white stems, green leaves with green/white petioles, and white flowers. This type is generally cultivated in South-East Asia (Indonesia: kangkung darat; Malaysia: kankung putih, kankung darat; Thailand: phakbung-chin). In the Philippines and Taiwan two cultivars of white-flowering kangkong are distinguished: one with broad leaves and one with narrow and pointed leaves. Recently, cultivars have been developed in Thailand, including 'Loet Phan nr. 1' (green stems, quick and uniform emergence), 'Bai Phai nr. 5' (dark green leaves and stems, very narrow leaves known as bamboo-leaf type), and 'Prachan nr. 9' (yellow green leaves, whitish stems). The Thai landrace Phakbung-chin is still very important.

Ecology Probably kangkong is a quantitative short-day plant. It produces optimum yields in the lowland humid tropics, with stable high temperatures and short-day conditions. Kangkong is a typical lowland vegetable. It is rarely grown above 700 m because at average temperatures below 23°C the growth rate is too slow to make it an economic crop. At higher latitudes (North Thailand, North Vietnam, Hong Kong), it is mainly grown as a summer vegetable. Adapted to a wide range of soil conditions, kangkong has a relatively high soil moisture requirement and clay soils are generally suitable. Soils with a high level of organic material are preferable. The optimum pH is between 5.3–6.0.

Propagation and planting Kangkong can be grown in various ways. In Malaysia, Taiwan, Thailand and Vietnam it is usually cultivated as an upland crop (e.g. the 'Chinese market-gardening system' or the 'ditch-and-dike system' in Thailand), but in Indonesia it is mainly grown in water (e.g. 'paddy-field kangkong' or 'floating kangkong').
- Upland or dry cultivation. Under these conditions kangkong roots in soils which are not inundated. Seeds are either broadcast or sown in rows (in Malaysia, Singapore and Thailand). In Thailand the seeds are sometimes soaked for 12–24 hours in water before sowing, but in the leading production areas, soaking is not practised. When seeds of reliable quality are available, Thai farmers use about 80 kg/ha. If necessary, soils are limed before sowing (2500 kg/ha). Besides seed, cuttings are used for propagation in China and Taiwan. Cropping takes place on beds. Plant densities may vary between 30–170 plants/m^2. A quick and uniform emergence is an important consideration for farmers.
- Paddy-field or wet cultivation. Paddy-field kangkong is practised in Indonesia, the Philippines, Thailand, China, Taiwan, Hong Kong and India. Planting may be direct by cuttings or by transplanting 6-week-old seedlings raised on nursery beds (in China, Taiwan and Hong Kong). Planting densities may vary widely from 200 000–1 500 000 cuttings or seedlings per ha. Floating kangkong is mainly grown on a commercial scale in ponds and rivers in Thailand, China and Taiwan. Integrated systems with fish, kangkong, pigs and chickens are practised. There is no root contact with the soil. Cuttings are anchored in the water by bamboo sticks forming a kind of bed.

Husbandry
- Upland cultivation. Weeding and watering are normally done by hand. Chicken, duck and pig manure are used as a basic application in Thailand, Malaysia and Singapore. Night soil is no longer permitted as manure in these countries. Fertilizers (e.g. ammonium sulphate, urea) are used as a top dressing immediately after sowing and 10–15 days later. In China, night soil is the most important fertilizer for kangkong. Application of higher levels of nitrogen fertilizer does not solely increase yields; leaf/stem ratios and dry matter content, especially of stems and petioles, decrease while nitrate content increases. Therefore, the amount of nitrogen available in the soil plus that provided as fertilizers should be monitored to avoid unacceptably high amounts of nitrate in the produce.
- Paddy-field cultivation. The water level is raised according to the development of the crop. Young plants cannot withstand flooding. In China and Hong Kong night soil is applied diluted with irrigation water. In Taiwan, a basic application of 10 t/ha of cow dung is followed by a top dressing of 50 kg/ha of ammonium sulphate after each harvest. In the Bangkok area about 300 kg of NPK fertilizer is commonly applied twice a month. In Indonesia farmers apply 150–300 kg/ha of urea after each harvest. Cultivation is terminated in the event of low temperatures in 'winter' (in China, Taiwan and Hong Kong), flowering (in Thailand), or serious disease, pest or weed problems.

Diseases and pests Owing to the short growing period of one crop of upland kangkong, diseases and pests do not cause much harm. Where ratooning is practised they can become a nuisance. White rust (*Albugo candida*) is reported from Thailand, Indonesia, Malaysia, Singapore and Hong Kong. Damping-off of seedlings caused by *Pythium* sp. may occur, and occasionally *Cercospora* leaf-spot. Root knot nematodes (*Meloidogyne* spp.) may become troublesome in ratoon cropping. Caterpillars of *Spodoptera litura* and *Diacrisia strigatula* and aphids may cause serious damage. Chemical control is a general practice, regardless of the hazards of toxication.

Harvesting Consumers have specific preferences with regard to the quality of the product, e.g. number of leaves, stem length, percentage of fibre, taste.

- Upland cultivation. Harvest takes place from 20–50 days after sowing. In Thailand, Malaysia, Singapore, Taiwan and China, uprooting the plants 20–30 days after sowing is common practice. The stems of these seedlings are big and tender but crisp. Ratooning is only practised in home gardens.
- Paddy-field cultivation. Harvesting is done by cutting young shoots one to two months after planting, and subsequently at regular intervals. In Indonesia and the Philippines plants are cut about 5–10 cm above ground level every 4–6 weeks. The stems are thinner but more fibrous and tough when compared to upland kangkong.

Yield Under upland cultivation, yields per crop range from 7–30 t/ha of fresh produce, depending largely on the cultivation period. Yields per year are up to 400 t/ha of fresh produce. Under wet cultivation, yields are difficult to compare because cultivation periods differ greatly. Annual yields of 24–100 t/ha are reported. For floating kangkong an annual production of 90 t/ha of fresh produce is reported for Thailand.

Handling after harvest Shoots of paddy-field kangkong are tied into bundles and transported to the market. Entire plants of upland kangkong are washed or wetted and sometimes wrapped in plastic to prevent wilting. In Taiwan, bundles are packed in layers of approximately 15 cm in bamboo crates. Crushed ice is placed between the layers, sandwiched between sheets of banana leaves.

Genetic resources Germplasm is available at the Asian Vegetable Research and Development Center (AVRDC) in Taiwan and at national research institutes in South-East Asia. A collection of at least 50 landraces of kangkong is available at the Kasetsart University in Bangkok (Thailand).

Breeding Not much breeding work has been carried out on the crop in South-East Asia. A seed company in Thailand has selected some superior cultivars.

Prospects Gradually the seed-propagated upland kangkong will become more important at the expense of the vegetatively propagated paddy-field kangkong. Research should focus on the improvement of cultural practices, especially regarding fertilizer application and control of insect damage. Breeding efforts should concentrate on obtaining productive cultivars with acceptable quality that are well adapted to specific environments and resistant to white rust.

Literature |1| Cornelis, J., Nugteren, J.A. & Westphal, E., 1985. Kangkong (Ipomoea aquatica Forssk.): an important leaf vegetable in South-East Asia. Review Article. Abstracts on Tropical Agriculture 10 (4): 9–21. |2| Edie, H.H. & Ho, B.W.C., 1969. Ipomoea aquatica as a vegetable crop in Hong Kong. Economic Botany 23(1): 32–36. |3| Linnemann, A.R., Louwen, J.M., Straver, G.H.M.B. & Westphal, E., 1986. Influence of nitrogen on sown and ratooned upland kangkong (Ipomoea aquatica Forssk.) at two planting densities. Netherlands Journal of Agricultural Science 34: 15–23.

E. Westphal

Lactuca indica L.

Mant. pl. 2: 278 (1771).
COMPOSITAE
$2n = 18$

Synonyms *Lactuca brevirostris* Champ. ex Benth. (1852).

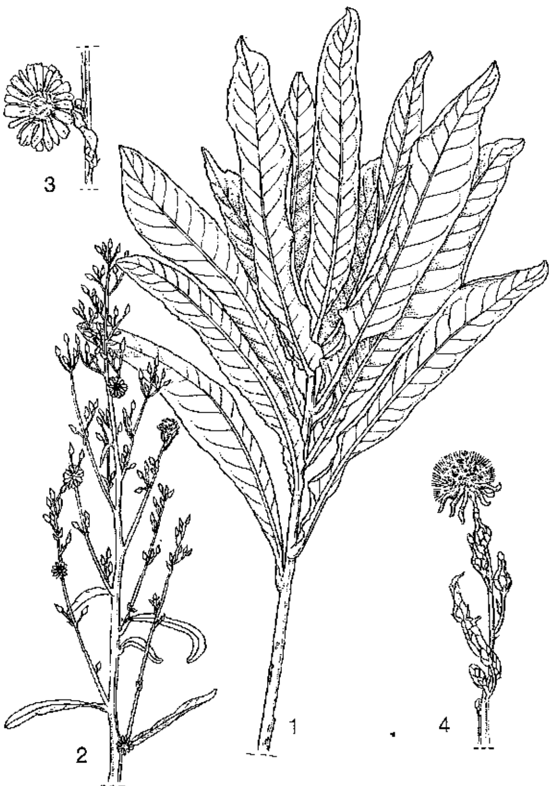
Vernacular names Indian lettuce (En). Indonesia: komak, lampenas (Sundanese), sawi rana (Javanese). Malaysia: daun panjang. Philippines: gilgiloy (Bisaya), batudan (Bontoc), gatudan (Kankanai). Vietnam: di[ees]p d[aj]i, rau b[oof] c[os]c, b[oof] c[oo]ng anh.

Origin and geographic distribution *L. indica* is native to the warmer parts of China, Taiwan, and southern Japan, where it occurs wild and cultivated. It has been introduced into South-East Asia, probably by Chinese immigrants, and is relatively common in Indonesia and Malaysia, where it sometimes occurs as an escape from cultivation.

Uses Indian lettuce is grown for its leaves. They are consumed raw, boiled or steamed. Leaves are also used for wrapping and frying fish. Further-more, the leaves are considered tonic, digestive and depurative in traditional medicine. In Taiwan it is grown as feed for geese. Silkworm can be fed with the leaves as a substitute for mulberry.

Production and international trade Indian lettuce is grown for local consumption on a small scale. It is fairly common in the mountainous areas of Puncak and Bandung (West Java, Indonesia) and in the Cameron Highlands (Malaysia). It is also commonly grown as a barrier crop in vegetable farms in the lowlands of Malaysia. No statistics are available.

Botany Perennial, erect, tillering, laticiferous herb, with radical rosette when young, up to 2 m tall when flowering. Leaves alternate, sessile, oblong-lanceolate, very variable in shape and dimension, with narrowed base and acute apex, 5–35 cm × 1–10 cm, often with a red midrib. Inflorescence terminal, paniculiform or corymbiform, 50–100 cm long, many-branched, with numerous relatively small (2 cm × 5–7 mm) flower heads; involucral bracts partly ovate (outer ones), partly oblong-linear-lanceolate (inner ones); flowers ligulate,



Lactuca indica L. – 1, leafy shoot; 2, inflorescence; 3, flower; 4, infructescence.

bright yellow, patent or obliquely erect. Fruit a flat elliptical achene, 3–4 mm × 2 mm, black, shortly beaked, hard, at the top with a tuft of white hairs. Mature plants produce basal shoots.
In Taiwan and Japan, several forms differing mainly in leaf-form have been distinguished as botanical varieties or formas. The leaves vary from undivided linear-lanceolate to deeply pinnatifid oblong.

Ecology Indian lettuce is cultivated from the lowlands up to 2000 m altitude. Sometimes it grows wild as an escape from cultivation in ravines, waste places, field and forest borders, roadsides, and plantations of perennial crops. It prefers fertile, well-drained soils with a high organic matter content, but tolerates a wide range of soils.

Agronomy Propagation is by seed, which germinate 3–4 days after sowing, or by root cuttings, which easily develop buds. Seeds are usually sown on a seed-bed and seedlings transplanted when they are 5–10 cm tall, 3–4 weeks after sowing. Cultivation methods are similar to lettuce (*L. sativa* L.). Indian lettuce can be planted in field beds at a spacing of 30 cm × 30 cm. Because of its tall stature it is often planted in the middle of field beds to provide light shade for other vegetables. It is commonly grown on dikes of rice fields and in home gardens.
Cucumber mosaic virus (CMV) may cause stunted growth, reducing leaf quality.
When plants are about 2 months old and 50 cm tall, harvesting of individual leaves starts and continues until flowering interferes. Plants may then be cut near ground level for axillary buds to form a ratoon crop.

Genetic resources and breeding Some accessions of *L. indica* are usually maintained in germplasm collections of lettuce (*L. sativa*) and related species, but there are no specific collections for Indian lettuce.
There are clear breeding barriers between the '*sativa-serriola*' and '*indica*' group.

Prospects Indian lettuce has maintained a niche in the market beside more productive salad crops. Very little information on this crop exists and that alone is sufficient reason for more research attention.

Literature |1| Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 137–138. |2| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische groenten', 1931).

Asher & Co., Amsterdam, the Netherlands. pp. 135–137. |3| Simmonds, N.W. (Editor), 1976. Evolution of crop plants. Longman, London, United Kingdom. pp. 39–41.

Roemantyo

Lactuca sativa L.

Sp. pl.: 795 (1753).
COMPOSITAE
$2n = 18$

Synonyms *Lactuca serriola* L. var. *sativa* Moris (1840–1843), *L. scariola* L. var. *hortensis* Bisch. (1851), *L. scariola* L. var. *sativa* Boiss. (1875).

Vernacular names Lettuce (En). Laitue (Fr). Indonesia: slada, salada bokor (Sundanese), selada, sladah (Javanese). Malaysia: salad, selada. Papua New Guinea: letis. Philippines: letsugas (Tagalog), tawa (Marinduque). Cambodia: sallaat. Thailand: phakkat-hom, phaksalat (central), phakkat-kaeo (northern). Vietnam: rau di[ees]p, x[af] l[as]ch, di[ees]p xo[aw]n.

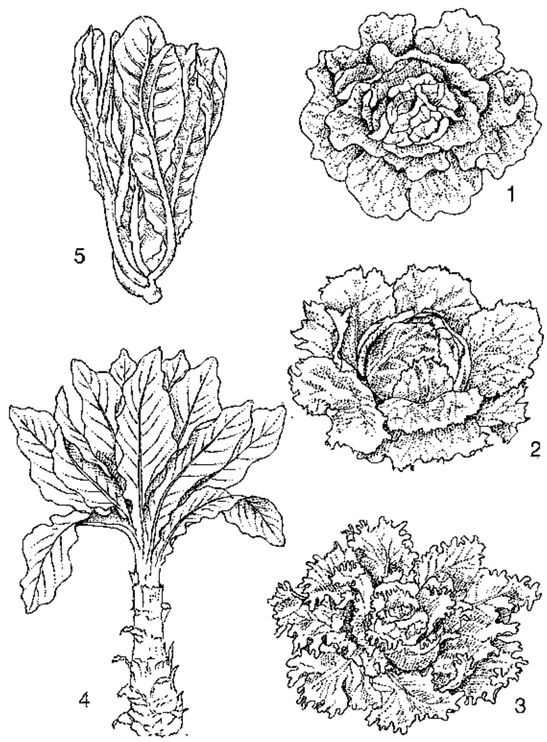
Origin and geographic distribution The origin of lettuce is believed to be in Asia Minor or the Middle East. It was known as a vegetable and for its medicinal properties as early as 4500 BC. It was a popular vegetable of the Greek and Romans. In western Europe, the headed types have been known since the 14th Century but the leafy types have been known for much longer. The cultivated lettuce is probably derived from the wild lettuce *L. serriola*. The chromosome number is the same and crosses are easily made. Numerous genetic differences in cultivated lettuce types, however, suggest a polyphyletic origin. Stem lettuce is very popular in China and Taiwan. Lettuce, especially the headed type, is currently the world's most important salad crop and a popular vegetable in almost all countries of the world.

Uses Lettuce is grown for its leaves, which are usually eaten raw as a salad with a dressing of vinegar. Occasionally it is used as a cooked vegetable. Stem lettuce is grown in China and Taiwan for the fleshy stem, which is prepared by cooking; in South-East Asia (Indonesia, Malaysia and Vietnam in particular) it is grown for the leaves ('siomak', 'yaomak'). Dried lettuce leaves are sometimes used in cigarettes as a substitute for tobacco. In Egypt, the oil extracted from the so-called oilseed lettuce (possibly a transitional type between *L. sativa* and *L. serriola*) is used as an aphrodisiac.

Production and international trade There are no statistics on cultivated areas and production in South-East Asia, since lettuce is a small part of the group of leafy vegetables which also includes kangkong and amaranth. In temperate areas lettuce is one of the leading commercial vegetables, whereas in the tropics it is a secondary vegetable of small but increasing commercial importance. The total area of lettuce registered in European Community countries is about 90000 ha with a production of 2.0 million t (22 t/ha); 16% of the area and 23% of the production is from greenhouses. The total annual world production is estimated at about 3 million t from a total area of 300000 ha.

Lettuce is not traded much internationally, except in Europe. Since it is a very perishable product, it is mainly produced near big cities. Crisphead lettuce, which is less perishable, is produced in some South-East Asian countries as an export product, e.g. from Malaysia to Singapore and from Thailand and Vietnam (Dalat) to Hong Kong.

Properties Per 100 g edible portion, the leaves contain: water 94 g, protein 1.2 g, fat 0.2 g, fibre



Lactuca sativa L. – 1, habit (butterhead lettuce); 2, habit (crisp lettuce); 3, habit (bunching lettuce); 4, habit (stem lettuce); 5, habit (cos lettuce).

0.7 g, ash 0.7 g. Lettuce is quite low in carbohydrates, protein and fat, and the energy value (50 kJ/100 g) is low. There are considerable differences in nutritional properties among lettuce types. Headed types with a low chlorophyll content (light green leaves) have fewer micronutrients than leafy types; the dark green types have considerably more carotene, Fe and vitamin C. Butterhead lettuce contains about 30 mg Ca, 1 mg Fe, 1.5 mg ß-carotene, 0.05 mg vitamin B_1, 0.08 mg vitamin B_2, 0.4 mg niacin and 10 mg vitamin C. For crisphead lettuce these values are lower.
In some western countries the presence of free nitrates in lettuce and other leafy vegetables is seen as a negative quality factor causing health problems. In the Netherlands the maximum content of NO_3 tolerated in summer lettuce is 2.5 mg per g fresh weight. The nitrate content strongly decreases with increasing light intensity and consequently it is no problem in tropical countries.
The 1000-seed weight is 0.8–1.2 g.

Description A very variable, glabrous, lactiferous, annual or biennial herb, 30–70(–100) cm tall, usually forming a dense basal rosette and later a tall, branched, flowering stem. Taproot slender at first, later thickening, reaching 1.5 m depth. Stem at first short with radical leaves arranged spirally, in cv. group Stem Lettuce developing into a 30–50 cm long, fleshy organ. Leaves variously arranged, depending on cultivar, in more or less compact heads or not in heads; shape, size and colour differing with cultivar; rosette leaves undivided to runcinate-pinnatifid, sometimes curly and fringed, shortly petiolate, green or sometimes with red anthocyanin pigment; stem leaves becoming progressively smaller, ovate to orbicular in outline, entire, cordate-amplexicaul, sessile, not held vertically. Inflorescence a dense, corymbose, flat-topped panicle with flowers arranged in heads; involucre 10–15 mm long, consisting of 3–4 rows of lanceolate or ovate bracts; head with 7–15(–35) florets, all ligulate and hermaphrodite, yellow, exserted above the involucre; stamens 5 with connate anthers; stigma bifid. Fruit a narrowly obovate achene, 3–8 mm long, compressed, 5–7-ribbed on each side, white, yellowish, grey or brown; tip constricted into a narrow beak, surmounted by a white pappus of 2 equal rows of soft hairs.

Growth and development Germination is epigeal. The seed germinates within 4 days, viable seed even within one day, at temperatures from 15–25°C. Lettuce seed often shows dormancy, especially when the seed has been stored at high temperatures and is sown at a soil temperature above 24°C, which is the normal situation in tropical lowlands. The best remedy to break the dormancy is by storing the wetted seed in a refrigerator at 2–5°C for 1–3 days. Growth of the young plants is exponential, slow at first and very fast in the last weeks before the harvest stage. The rosette formation becomes apparent in the third week after sowing, and the head formation in the headed types two weeks later. Depending on growing conditions and cultivar the head is fully formed and ready for harvesting about two months after sowing. Plants 2–3 months old start bolting. Flower stalk development of headed cultivars is stimulated by removal of the upper part of the head. The flowering stage may last 1–2 months. The flowers are generally open for 1–2 hours and do not open all at once. Lettuce is almost completely selfpollinated before the flowers open. Seed is produced abundantly. Seed matures in 9–13 days after anthesis, depending on e.g. temperature.

Other botanical information The many hundreds of cultivars may be grouped into cultivar groups. However, intermediate types exist and a clear-cut distinction is difficult. Below a practical grouping is presented, mainly derived from the classification proposed by Rodenburg.

- Cv. group Butterhead Lettuce (synonyms: var. *capitata* L. p.p., var. *capitata* L. nidus *tenerrima* Helm): head lettuce. Soft solid heads of overlapping leaves; inner leaves thin, oily, buttery in texture. Originated in western Europe. The most popular lettuce of cool temperate areas; less popular in the tropics. Cultivar type: 'May Queen'; numerous cultivars.
- Cv. group Crisp Lettuce (synonyms: var. *capitata* L. p.p., var. *capitata* L. nidus *jaggeri* Helm): iceberg lettuce, ice lettuce, cabbage lettuce. Thick crispy leaves with prominent flabellate veins and midribs; non-heading or slightly heading types occur next to cultivars with heavy firm cabbage-like heads. Originated in France, very popular in the United States. The most popular type in warm temperate and subtropical areas and in the cooler tropical areas (highlands, cool season in the lowlands). Cultivar type: 'Great Lakes'; numerous cultivars.
- Cv. group Cos Lettuce (synonyms: var. *romana* hort. ex Bailey, var. *longifolia* Lamk): romaine lettuce. Long narrow leaves, forming a tall, loose, upright, cylindrical head. Eaten raw or cooked as spinach. Originated in southern Europe. Fairly common in the tropics. Cultivar

type: 'White Parish Cos'; many cultivars.

- Cv. group Bunching Lettuce (synonyms: ssp. *acephala* Alef. var. *secalina* Alef., var. *crispa* L.): leaf lettuce, loose-leaf lettuce, curled lettuce, cutting lettuce. Thin, broad, smooth or curled or crinkled, green or reddish leaves in a loose rosette or on a short stem, marketed by bunching of 3–10 plants. Very common in tropical areas. Cultivar types: 'Salad Bowl', 'Simpson', 'Oakleaf'; many cultivars and landraces.
- Cv. group Stem Lettuce (synonyms: var. *asparagina* Bailey, var. *angustana* Irish ex Bremer): asparagus lettuce, stalk lettuce, celtuce. In the United states called 'celtuce' because peeled stems are used as celery stalks and the leaves are used as lettuce. Grown for the fleshy 30–50 cm long, 3–6 cm thick stem which has a crisp texture and a faint lettuce taste. The stem bears many leaves with a rosette at the apex. Young leaves also edible and popular in South-East Asia. Originated in China, spreading to South-East Asia (Indonesia, Malaysia, Thailand). Cultivar type: 'Celtus'; many cultivars and landraces.
- Cv. group Latin Lettuce: grasse. Small dark-green plants growing in a rosette or forming a loose head, with thick leathery leaves. Tolerant of high temperatures. Popular in France. Cultivar types: 'Sucrine', 'Creole'.

Ecology Lettuce grows best at moderate day temperatures of 15–20°C and cool nights. In the tropics it thrives best in the highlands and during the coolest season in the lowlands. Headed cultivars usually form only a loose head at temperatures above 25°C. Crisphead lettuce is more tolerant of high temperatures than butterhead lettuce. When day temperatures rise above 28°C the heads will be very loose or will not form. For this reason, most lettuce grown in tropical lowlands is leaf lettuce. Lettuce shows a slight quantitative long-day reaction, but most modern cultivars are almost day-neutral. Bolting is strongly promoted by high temperatures.

Lettuce can be grown on any soil type with a good structure and high fertility. The water-holding capacity is important because the root system of lettuce is relatively small, which makes the crop very vulnerable to drought. Lettuce is often grown on slightly alkaline sandy-loam soils. It does not tolerate acid soils (pH < 6).

Propagation and planting Many lettuce farmers in South-East Asia use seed of their own selection. If not properly stored, lettuce seed rapidly loses its viability. Plants of headed types and also stem lettuce are normally raised in a nursery. The seeds are sown in a shaded seed-bed and are pricked out one week later (in the two-leaf stage) in banana-leaf pots or soil blocks of 4 cm × 4 cm. The sowing rate is about 200 g/ha.

Leaf lettuce is usually sown directly in the field in drills 30 cm apart. For this cultivar group a regular plant density is less important. Seed requirement for direct sowing is about 0.5 kg per hectare. In heavily mechanized cultivation systems in western countries, headed lettuce cultivars are also sown directly in the field using precision drilling machines, but this practice is inappropriate for small farmers in the tropics. Crisphead lettuce is planted out in the field at 30 cm in the row and 50 cm between the rows (60 000 plants/ha) or at 35 cm × 35 cm (80 000 plants/ha). Butterhead lettuce may be planted more closely, depending on the mature head size of the cultivar, usually at 30 cm × 30 cm.

Husbandry Young lettuce cannot compete with fast-growing weeds. Several weedings are needed in the first month when the soil surface is not yet covered by the lettuce plants. Further, the water supply must be very regular. The evapotranspiration increases fast, from 2–3 mm/day in the first weeks to 6–8 mm for the fully grown crop. Water shortage causes Ca deficiency in young leaves resulting in tip burn, an internal necrosis of the leaf margins in the head followed by bacterial rot.

Lettuce is a crop with a moderately high uptake of minerals. Depending on the soil conditions, a suitable fertilizer recommendation is 30 t/ha of farmyard manure combined with 50 kg N, 100 kg P_2O_5 and 80 kg K_2O before planting; a side dressing of 50 kg/ha N is given 3 weeks after planting and again 3 weeks later if needed. The mineral uptake (N, K) is low during the first month after sowing and highest in the last weeks before harvest. Too much nitrogen makes the crop susceptible to tip burn and diseases, and increases the content of free nitrates in the harvested product.

Diseases and pests Apart from the physiological disorder tip burn, the most serious diseases of lettuce in the tropics are mosaic, bottom rot and downy mildew. Mosaic is caused by lettuce mosaic virus (LMV) and other viruses and may be controlled by the use of healthy seed, control of aphids and immediate removal of diseased plants. Bottom rot caused by *Rhizoctonia solani* commonly occurs under wet conditions. The symptoms are a slimy rotting of the underside of the plant, progressing into the head. *Sclerotinia* causes a wet rot of the entire plant, beginning at the stem base. Downy mildew caused by *Bremia lactucae* is the most serious disease of lettuce in temperate areas and in cooler locations in the tropics. The best control of bottom rot and *Sclerotinia* is good sanitation, crop rotation and drainage. Downy mildew is controlled by using cultivars with resistance to the relevant race of the fungus or by spraying with fungicides. Damping-off (*Pythium*), grey mould (*Botrytis*) and leaf-spot (*Cercospora*) are also reported on lettuce in the tropics.

The most serious pests are aphids, especially in headed lettuce, because they cannot easily be controlled by spraying with chemicals, which is, moreover, risky because of residues. Other pests are *Agrotis* cutworm, army worm (*Spodoptera*) and other caterpillars, leafhoppers, snails and slugs, and root knot nematodes. The insect pests are usually controlled by chemical sprayings. Nematodes in lettuce are kept under control by crop rotation, disinfection of the seed-bed or nursery soil by heating, and the use of ample manure.

Harvesting The time to harvest depends upon the cultivar and purpose. Harvesting of headed lettuce is commenced when the heads are fully developed, usually 60–80 days after planting. Harvesting is done by cutting the plants at their base or, for bunching lettuce, by uprooting. Old outer leaves are trimmed off. Leaf lettuce can be harvested at any time from the young stage until bolting starts. The younger the lettuce, the more tender it will be, but also the lower the yield. Leaf lettuce is harvested between 30–50 days after sowing.

Yield For headed lettuce a yield of 70% or more of the number of plants originally planted may be considered a satisfactory result. Successful farmers may reach 90%. The average world yield is 10 t/ha. A harvest of 50 000 heads/ha with an average weight of 300 g yields 15 t/ha. Yields above 20 t/ha are reported, but in the tropics the yield level usually reaches only 5–10 t/ha. Yields of leaf lettuce are lower than for headed lettuce (3–8 t/ha). Stem lettuce harvested at 80–100 days after planting may yield up to 20 t/ha.

Handling after harvest Lettuce wilts easily. The most suitable packing of headed lettuce (butterhead, crisphead) is in open-topped polythene bags which are put in crates or boxes. Cooling or packing with ice greatly improves keepability. Headed lettuce is further trimmed if old or damaged outer leaves are still present. Plants of headed cultivars which have not produced a head of marketable size are often uprooted and bundled in bunches of 3–8 plants. Uprooted lettuce in street markets is kept fresh by putting the roots in a basin with water, as is done with kangkong and amaranth.

Genetic resources Large germplasm collections of lettuce and wild *Lactuca* species are kept in the Netherlands (Centre for Genetic Resources, Wageningen), Commonwealth of Independent States (Vavilov Institute of Plant Industry, Petersburg), United Kingdom (Horticultural Research International, Wellesbourne), and the United States (USDA Agricultural Research Station, Salinas).

Lettuce was introduced into South-East Asia hundreds of years ago. Many local selections or landraces have developed which may contain valuable genes for disease resistances, heat tolerance, and other traits. There is a great risk of genetic erosion of this material, since seed companies promote improved cultivars.

Breeding Many hundreds of cultivars have been bred in temperate countries (Europe, North America, Japan) with a large variation of very specific characters. Resistance to mosaic and downy mildew is common, but not to tip burn and bottom rot. Low nitrate content is a selection criterion in temperate countries. Some selection criteria for tropical headed lettuce cultivars are a short growing period, slow bolting, large compact heads which are not easily damaged during transport.

Prospects Lettuce continues to increase in popularity in all tropical countries and will be universally grown for local markets and export. Research should focus on the selection of heat-tolerant cultivars and non-chemical control of diseases and pests.

Literature |1| Bantoc Jr, G.B., 1967. Lettuce. In: Knott, J.E. & Deanon Jr, J.R. (Editors): Vegetable production in South-East Asia. University of the Philippines Press, Los Baños, the Philippines. pp. 329–341. |2| Boukema, I.W., Hazekamp, Th. & van Hintum, Th.J.L., 1990. The CGN lettuce collection. Centre for Genetic Resources (CGN), Wageningen, the Netherlands. 53 pp. |3| Feráková, V., 1977. The genus Lactuca L. in Europe. Univerzita Komenského, Bratislave, Slovenia. pp. 67–68. |4| Kesseli, R., Ochoa, O. & Michelmore, R., 1991. Variation at RFLP loci in Lactuca spp. and origin of cultivated lettuce (L. sativa). Genome 34: 430–436. |5| Mansfeld, R., 1986. Verzeichnis landwirtschaftlicher und gärtnerischer Kulturpflanzen (ohne Zierpflanzen) [Register of agricultural and horticultural plants in cultivation (without ornamentals)]. Schultze-Motel, J. et al., editors 2nd edition. Springer Verlag, Berlin, Germany. pp. 1330–1333. |**6**| Purseglove, J.W., 1968. Tropical crops. Dicotyledons. Longman, London, United Kingdom. Vol. 1. pp. 74–77. |**7**| Rodenburg, C.M., 1960. Salatsorten [Lettuce types]. Instituut voor de Veredeling van Tuinbouwgewassen, Wageningen, the Netherlands. 228 pp. |**8**| Ryder, E.J., 1986. Lettuce breeding. In: Bassett, M.J. (Editor): Breeding vegetable crops. Avi Publishing Company, Westport, Connecticut, United States. pp. 443–474. |**9**| Thompson, H.C. & Kelly, W., 1957. Vegetable crops. McGraw-Hill Book Company, London, United Kingdom. pp. 255–269.

G.J.H. Grubben & S. Sukprakarn

Lagenaria siceraria (Molina) Standley

Publ. Field Mus. Nat. Hist. Chicago, Bot. Ser. 3: 435 (1930).

CUCURBITACEAE

$2n = 22$

Synonyms *Cucurbita lagenaria* L. (1753), *Lagenaria vulgaris* Seringe (1825), *L. leucantha* Rusby (1896).

Vernacular names Bottle gourd, calabash gourd, white-flowered gourd (En). Calebasse, courge bouteille (Fr). Indonesia: labu air, labu putih, kukuk (West Java). Malaysia: labu botol. Papua New Guinea: sel kambang, botol wara. Philippines: upo (Tagalog), tabungaw (Ilocano), kalubay (Bisaya). Cambodia: khlôôk. Laos: namz taux. Thailand: namtao (central), manamtao (northern), khi-luu-saa (Karen). Vietnam: b[aa][uf].

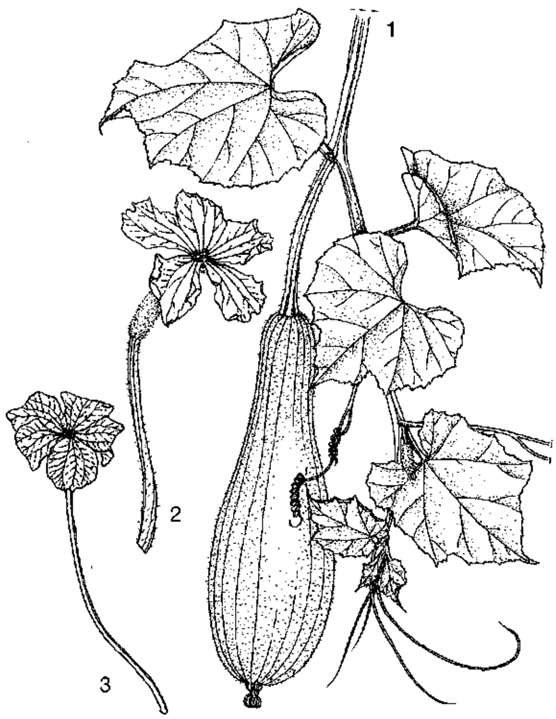
Origin and geographic distribution Bottle gourd probably originated in tropical Africa and now has pantropical distribution. It could have been spread by ocean currents to the shores of the New World. More than 10 000 year-old archeological records of its association with man exist in both hemispheres. It is the only crop known to have been cultivated in pre-Columbian times in both the Old and the New World.

Uses The young fruits of selected cultivars are used as a vegetable, usually boiled, fried or in stews. Cultivars differ markedly in sweetness or bitterness. Carefully selected cultivars are comparable to the popular summer squashes of temperate regions. Young shoots are frequently consumed as a green. Bottle gourd seeds are a popular snack food; oil from the seeds has been used to some extent in Africa. The green fruit, made into syrup, is employed medicinally as a pectoral against chest pains. The hard shells of dried mature fruits are used for containers, hats, decorative handicrafts, floats and musical instruments. In the central highlands of New Guinea, fruits of the elongated type are used as 'holim' or 'penis sheath.

Cultivars with known resistance to soilborne diseases and tolerance to stress environments are used as rootstocks for grafting melon, watermelon and cucumber in Japan and China.

Production and international trade In most places, cultivation and utilization of bottle gourd is still a small-scale undertaking for home consumption and local markets. Economic data are scarce. In the Philippines, the average annual production is about 20 000 t from 2500 ha. Cultivated area in Indonesia is also about 2500 ha.

Properties The edible portion of immature fruits of bottle gourd is about 84%. Per 100 g edible portion, they contain: water 95 g, protein 0.5 g, fat 0.1 g, carbohydrates 3.5 g, vitamin A 10 IU, vitamin B_1 0.04 mg, vitamin B_2 0.02 mg, niacin 0.4 mg, vitamin C 11 mg, Ca 16 mg, Fe 0.4 mg, P 14



Lagenaria siceraria (Molina) Standley – 1, flowering and fruiting shoot; 2, female flower; 3, male flower.

mg. The energy value is about 63 kJ/100 g. The seeds contain 45% oil. The weight of 1000 seeds averages 150 g.

Description Monoecious annual vine with a long ribbed stem and strong tendrils. Tendrils usually bifid with one long and one shorter branch; petioles up to 20 cm long; leaves simple, alternate, ovate-reniform or suborbicular, up to 30 cm in diameter, undivided or obscurely 5–9-lobed, dentate, pubescent, musky-scented. Flowers axillary, solitary, white, up to 12 cm in diameter; calyx campanulate, 5-lobed; petals 5, free; male flowers on long pedicels, 5–25 cm long; stamens with 3 free filaments, anthers lightly cohering, but not connate; female flowers on short pedicels, 2–7 cm long; ovary with 3 placentae and numerous ovules, completely clothed with white gland-tipped hairs, stigmas 3, thick, bilobed. Fruit a pepo, very variable in size and shape, often globular, bottle- or club-shaped, up to 1 m or more long, with hard durable rind; flesh white and soft. Seed corky, broad and flat, or narrow and two-pronged, 10–25 mm long, whitish or brownish.

Growth and development Emergence takes 5–7 days from sowing. The vining stage starts 14 days after emergence and is characterized by rapid vine elongation. It occurs simultaneously with the growth of tendrils and lateral stems. Growth slows down at the onset of flowering which starts 55–65 days after sowing and continues throughout the cropping period of 6–7 months. A number of male flowers are produced before the female flowers appear. The ratio of female to male flowers is higher under cool temperatures and can be increased with growth-regulating substances (e.g. maleic hydrazide). The number of female flowers is greatly reduced if the number of maturing fruits per plant exceeds 2 to 3. Continuous picking of young fruits prolongs crop duration. Flowers open in the late afternoon and are pollinated by insects, mainly bees. Pollen is usually abundant. The stigmas are receptive from 6 hours before to 36 hours after anthesis. For seed production, the fruits need 2–3 months to mature.

Other botanical information The existence of two subspecies of *L. siceraria*, one domesticated in Asia (ssp. *asiatica* (Kob.) Heiser) and the other in both Africa and the New World (ssp. *siceraria*), has been confirmed but seed trade has obscured the subspecific distinction.

Improved cultivars are available from seed companies and research institutions in the Philippines, Thailand, India, Japan and Taiwan. In the Philippines two types are used: light green, and dark green with light green spots. In Japan, bottle gourd cultivars are classified into two groups based on the usage. The 'yugao' group is for vegetable use and is characterized by elongated fruits (90–100 cm long, 12–25 cm wide). The 'hyotan' group is used for making containers and decorations.

Ecology Bottle gourd can be grown year-round from sea-level up to 1600 m altitude, but the vegetable types are most common in the hot and humid lowlands. It tolerates cool but frost-free temperatures. Short days promote flower formation but have no effect on sex expression. Soils should be light and well-drained, with pH 6–7.

Propagation and planting Bottle gourd is usually direct-seeded. Transplanting can be done if the amount of seed is limited. Before planting, seeds may be soaked in water overnight to achieve fast and uniform emergence. During the wet season, the seeds are planted on mounds, whereas during the dry season they are planted in depressions made during land preparation. 2–3 seeds are sown per hill. Weak or diseased seedlings are thinned out 3–4 weeks after emergence and one plant retained per hill. When trailing over the ground, plants should be spaced about 1 m in the row and 2 m between the rows (5000 plants/ha). When staked the density may be increased to 10 000 plants/ha. Application of fully decomposed manure or compost is beneficial and these should be incorporated into the soil during land preparation.

Husbandry Bottle gourd is sensitive to excessive soil moisture which favours disease infection, in particular stem rot. Furrow irrigation is preferable and is generally done at weekly intervals during the driest part of the year. During the wet season adequate drainage should be provided. Bottle gourd is shallow-rooted with an extensive lateral root system. Cultivation must be minimized during the fruiting stage. Manual weeding near the base of the plants is recommended. The rate of fertilizer application depends on soil factors and weather, but 40–60 kg/ha N, 40–60 kg/ha P and 60–80 kg/ha K can be taken as a general guideline.

To check growth, growing points are often nipped out. Assisted pollination is sometimes practised. For better fruit quality, bottle gourd is best grown on trellises. The fruits can hang straight, and the natural forms of the fruits can be further varied by artificially restricting growth with bands. When trailing over the ground, it is advisable to spread dry straw or grass on the ground to keep the developing fruits from contact with wet soil.

Diseases and pests In the hot humid tropics, diseases are the major constraint. They are more destructive to bottle gourd than insect pests. Among the major diseases are anthracnose (*Colletotrichum lagenarium*) during the wet months, and powdery mildew (*Erysiphe cichoracearum* and *Sphaerotheca fuliginea*) during the dry season. An unknown virus and *Sclerotium* basal stem rot also attack the crop. Sanitation (removal of infected leaves) and good cultural management are recommended to prevent disease build-up.
Fruit flies (*Dacus* spp.) and leaf folders, which can damage the fruit skin, are the most important insect pests.

Harvesting Fruits develop fast and require much attention at harvest time. For use as a vegetable it is difficult to specify the harvest stage, as young fruits of all ages are edible, including the ovary of the flower. Maximum yield, however, is obtained by harvesting the fruits as late as possible, when they are up to half of the mature size. The number of pickings per crop varies but may be as many as 20. The fruits are best harvested with a sharp knife, leaving about 5 cm of the fruit stalk attached to the fruit.
For use as containers, bottle gourds are permitted to mature on the vine. Seeds and pulp are scooped out and the rind is carefully dried.

Yield Under optimum conditions, crop yields of 40–60 t/ha can be realized. A yield level of 20–30 t/ha is considered good.

Handling after harvest Sorting is done after harvest to remove undesirable and abnormal fruits. Sorted fruits are packed in crates or bamboo baskets, lined with newspapers or banana leaves for transport to the market. Young fruits can be used up to 2 weeks after harvest. Longer storage causes rapid loss of water and hardening of the skin.

Genetic resources Sizeable germplasm collections of *L. siceraria* are maintained by the Institute of Plant Breeding at Los Baños (the Philippines), the Vavilov Institute of Plant Industry in St. Petersburg (Russia), the Southern Regional Plant Introduction Station in Georgia (United States), Cornell University in Geneva, New York (United States), and the USDA Research Station in Salinas, California (United States). Smaller collections are available at institutions in India, Taiwan, Ghana, Hungary and Guatemala.
Besides the bottle gourd, the genus *Lagenaria* Seringe comprises five wild perennial dioecious species occurring in Africa and Madagascar.

Breeding Populations of bottle gourd are heterozygous with considerable variation. In the Philippines, both open-pollinated cultivars and F_1 hybrids are being developed. The existence of hybrid vigour and its exploitation are well-documented. Main breeding objectives are high yield, resistance to diseases and pests, and tolerance to environmental stress. The possibility to transfer desirable traits from the wild to the cultivated species is still under investigation.

Prospects Bottle gourd is expected to remain a popular vegetable. Also its popularity as producer of calabashes seems lasting. This usage can be combined with the harvest of the seeds as a source of protein and oil. Breeding work is expected to lead to hybrids with the possibility of built-in disease resistances.

Literature |**1**| Esquinas-Alcazar, J.T. & Gulick, P.J., 1983. Genetic resources of Cucurbitaceae. International Board of Plant Genetic Resources (IBPGR), Rome, Italy. 101 pp. |**2**| Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 321–326. |**3**| Jeffrey, C., 1980. A review of the Cucurbitaceae. Botanical Journal of the Linnean Society 81: 233–247. |**4**| Martin, F.W., 1979. Vegetables for the hot, humid tropics. Part 4. Sponge and bottle gourds, Luffa and Lagenaria. Science and Education Administration, United States Department of Agriculture, New Orleans, United States. 19 pp. |**5**| Richardson, J.B., 1972. The pre-Columbian distribution of the bottle gourd (Lagenaria siceraria): a re-evaluation. Economic Botany 26: 265–273. |**6**| Tisbe, V.O., Deanon Jr, J.R. & Bantoc Jr, G.B., 1967. The cucurbits. In: Knott, J.E. & Deanon Jr, J.R. (Editors): Vegetable production in South-East Asia. University of the Philippines Press, Los Baños, the Philippines. pp. 138–166.

E.A. Widjaja & M.E.C. Reyes

Limnocharis flava (L.) Buchenau

Abh. Naturw. Ver. Bremen 2: 2 (1868).
BUTOMACEAE
$2n$ = unknown

Synonyms *Alisma flava* L. (1753), *Limnocharis emarginata* Kunth (1807), *L. plumieri* Richard (1815).

Vernacular names Sawah lettuce, velvet leaf, hermit's waterlily (En). Indonesia: genjer, bangeng, eceng. Malaysia: emparuk (Sarawak), jinjir, paku rawan. Laos: kaanz choong. Thailand: bonchin (southern), talapatrusi (central), nangkwak (central). Vietnam: k[ef]o n[ef]o, n[ee] th[ar]o.

Origin and geographic distribution *L. flava* is native to tropical and subtropical America and was introduced into South-East Asia more than a century ago. Now it occurs naturalized in Indonesia (Java, Sumatra), Malaysia, Thailand, Burma and Sri Lanka.

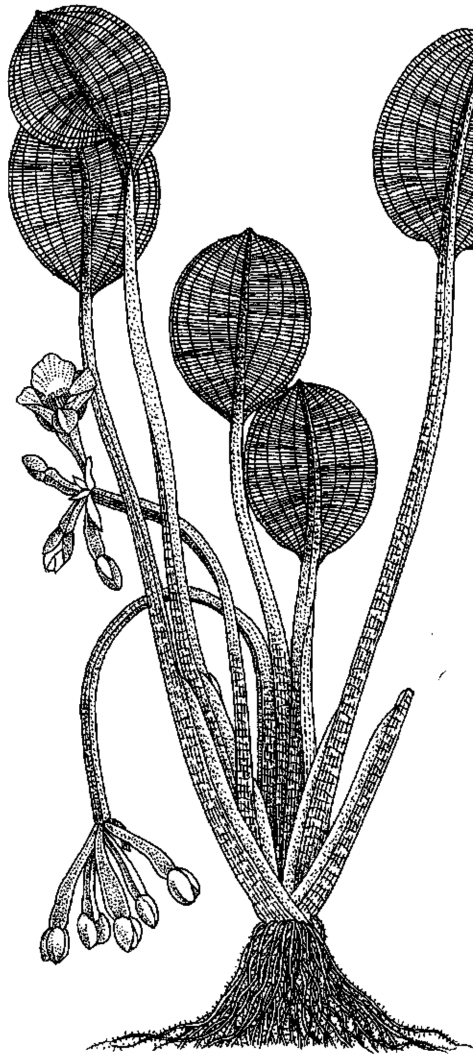
Uses Young leaves with petioles and young, unopened inflorescences are eaten as a vegetable in Indonesia, especially West Java, in Malaysia and in Thailand. Usually they are not eaten raw but heated above a fire or cooked for a short time. The older leaves have a bitter taste. Whole plants are given as fodder to pigs or fish. *L. flava* also serves as an ornamental plant in ponds. Plants are often ploughed in as green manure in rice fields.

Production and international trade In West Java *L. flava* is a common vegetable in markets and supermarkets but data on production are rare. In an integrated system of pisciculture and genjer cultivation, an Indonesian farmer harvested about 1000 bunches/ha in 3 months (1 bunch = 20 sprouts).

Properties Per 100 g edible portion *L. flava* contains: protein 1 g, fat 0.3 g, carbohydrates 0.5 g, vitamin A 5000 IU and vitamin B_1 10 IU. The energy value is 38 kJ/100 g.

Botany A perennial, erect, laticiferous, aquatic to swampy-terrestrial herb, 20–100 cm tall, strongly tillering. Leaves in a basal rosette, glabrous; petiole 5–75 cm long, thick, trigonous with many air chambers, sheathing at the base; leaf-blade orbicular, broad elliptic or ovate, 5–30 cm × 4–25 cm, yellow-green; nervation characteristic, main nerves 9–13 with numerous transverse parallel running secondary nerves. Inflorescence umbelliform, 3–15-flowered, peduncle up to 90 cm long, erect when flowering, downcurved when fruiting; flowers in the axils of membranous bracts; pedicel 2–7 cm long; sepals 3, ca. 2 cm long; petals 3, ovate to orbicular, 1.5–3 cm long, yellow; stamens more than 15, surrounded by a whorl of staminodes; ovaries 10–20. Fruit compound, composed of the ripe carpels forming together a globose or broadly ellipsoid body of 1.5–2 cm in diameter, enclosed by the sepals. Seed horseshoe-shaped, 1–1.5 mm long, provided with transverse crests, dark brown. Seedling with one, 8–11.5 mm long cotyledon, sheathing around the first leaf.

L. flava flowers the whole year round. The flowers open in the morning and close after a few hours. There is no record of any pollinating agent. After anthesis the sepals enlarge and surround the fruit whereas the petals become a slimy mass. When ripe the fruit carpels fall into the water where they release the seeds, which sink to the bottom. The downturned inflorescence which rests on the water surface often produces a new plant.



Limnocharis flava (L.) Buchenau – flowering plant.

Ecology *L. flava* grows in marshy, shallow locations like rice fields, (fish) ponds and ditches up to 1300 m altitude.

Agronomy *L. flava* can be cultivated the whole year round. It is propagated by layers, but propagation by seed is also possible. It needs a fertile soil; 1–2 weeks before planting, the soil should be enriched with organic fertilizer (10 t/ha). Planting distance is about 30 cm square. In a fertile sawah it will grow very fast and the leaves and inflorescences can be harvested after 2–3 months. If not harvested regularly the plant population will soon become too dense and should be renewed to maintain quality. After harvesting, the leaves and inflorescences are bundled together or separately and sold in small bunches.

Prospects *L. flava* is one of the most relished local vegetables of West Java and is also popular in Thailand; it deserves more attention in other areas. There is little information on this species. Cultivation in an integrated pisciculture system seems to be a good practice.

Literature |1| Djajadiredja, R. & Jangkaru, Z., 1979. Small scale fish/crop/livestock home industry integration. A preliminary study in West Java. Indonesian Agricultural Research & Development Journal 1(3/4): 1–4. |2| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische groenten', 1931). Asher and Co., Amsterdam, the Netherlands. pp. 88–90. |3| Soedirdjoatmodjo, M.D.S. 1986. Bertanam sayur daun [Growing leafy vegetables]. B.P. Karya Bani, Jakarta, Indonesia. pp. 43–46. |4| Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G., 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. pp. 118–119, 592–593. |5| van Steenis, C.G.G.J., 1954. Butomaceae. In: van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series I. Vol. 5(1). Noordhoff-Kolff, Djakarta, Indonesia. pp. 118–120.

M.H. van den Bergh

Luffa P. Miller

Gard. dict. abr. ed. 4. ord. alph. (1754).
CUCURBITACEAE
$x = 13$; $2n = 26$ (*L. acutangula, L. aegyptiaca*)

Major species and synonyms

- *Luffa acutangula* (L.) Roxburgh, Hort. Beng.: 70 (1814), synonym: *Cucumis acutangulus* L. (1753).
- *Luffa aegyptiaca* P. Miller, Gard. dict. ed. 8. ord. alph. (1768), synonyms: *Momordica luffa* L. (1753), *M. cylindrica* L. (1753), *Luffa cylindrica* (L.) M.J. Roemer sensu auct.

Vernacular names

- *L. acutangula*: Angled loofah, ridged gourd, Chinese okra (En). Papangay (Fr). Indonesia: oyong, gambas (Javanese), petola. Malaysia: ketola, petola sagi. Philippines: patola (Tagalog), kabatiti (Ilocano), buyo-buyo (Bisaya). Cambodia: ronôông chrung. Laos: looy. Thailand: buap, buap-liam (central), manoi-liam (northern). Vietnam: m[uw][ows]p kh[is]a, m[uw][ows]p t[aa][uf].
- *L. aegyptiaca*: Smooth loofah, sponge gourd, dish-cloth gourd (En). Eponge végétal, courge-torchon (Fr). Indonesia: blustru, emes (Sundanese), petulo panjang (Halmaheru). Malaysia: ketola manis, petola buntal. Philippines: patola (Tagalog), kabatiti (Ilocano), kabawang (Tagbanua). Cambodia: ronôông muul. Laos: bwàp khôm. Thailand: buap-hom (central), buap-klom (northern). Vietnam: m[uw][ows]p h[uw][ow]ng.

Origin and geographic distribution At present the genus *Luffa* is considered to comprise 7 species: 4 native to the Old World tropics and 3 to the New World tropics. The two major species described here are of Old World origin but it is not known from where exactly. *L. acutangula* is believed to originate from India where wild forms still occur. It is now cultivated in South and South-East Asia and occasionally in other tropical and subtropical areas. It sometimes grows wild as an escape from cultivation.

Wild forms of *L. aegyptiaca* occur from Burma to the Philippines and southwards to north-eastern Australia and Tahiti. It is not known where it was first domesticated. Now it is cultivated pantropically and it easily grows wild as an escape from cultivation.

Uses The immature fruits, young leaves and flower buds of both species are used as vegetables. The fruits are usually cooked or fried and used in soups or sliced and dried for later use. Young fruits of sweet cultivars may be eaten raw like cucumbers and small fruits are sometimes pickled. Mature fruits are inedible, becoming fibrous and very bitter due to the development of purgative substances. The mature fruits of *L. aegyptiaca*, which develop an internal fibrous skeleton in the form of a spongy network, are more important than the young fruits. These loofah sponges are easily extracted from ripe fruits by removing the rind and the seeds: most of the initially soft internal tissue (used as a vegetable) has disappeared by maturity. Loofah sponges became important commercially very before and during the Second World War as filters in several kinds of engines, for which no acceptable substitutes existed when Japan, the main producer, stopped exports because of the war. Because of their shock- and sound-absorbing properties they were also used in steel helmets and armoured vehicles. At present they are used as insulating material (sound, shock and temperature), bath sponges, scourers and in the manufacture of potholders, table mats, door and bath mats, insoles, sandals and gloves. The sponges of *L. acutangula* are little used because they are difficult to extract from the mature fruits.

The fibres, charred fruits, fresh fruits, seeds, leaves and the sap of the stem of the smooth loofah are used for medicinal and cosmetic purposes, especially in China and Japan. The seeds yield an edible oil.

Production and international trade Angled loofah is mainly produced as a home garden crop, whereas smooth loofah is an important field vegetable. Some export from Thailand occurs to Western Europe to provide the Asiatic community, mainly Chinese, with young fruits.

There are no clear statistics on the production of loofah. Japan is the main exporter of loofah sponges, followed by Brazil. Efforts to set up large commercial plantations in the tropics have failed. The United States is the main importer, with several million sponges per year.

Properties The edible portion of immature fruits is 70–80%. Per 100 g edible portion they contain: water 93 g, protein 0.6–1.2 g, fat 0.2 g, carbohydrates 4–4.9 g, Ca 16–20 mg, Fe 0.4–0.6 mg, P 24–32 mg, vitamin A 45–410 IU, vitamin B_1 0.04–0.05 mg, vitamin B_2 0.02–0.06 mg, niacin 0.3–0.4 mg, vitamin C 7–12 mg. The energy value is approximately 85 kJ/100 g.

Young leaves contain per 100 g edible portion: water 89 g, protein 5.1 g, carbohydrates 4 g, fibre 1.5 g, Ca 56 mg, Fe 11.5 mg, P 140 mg, ß-carotene 9.2 mg, vitamin C 95 mg.

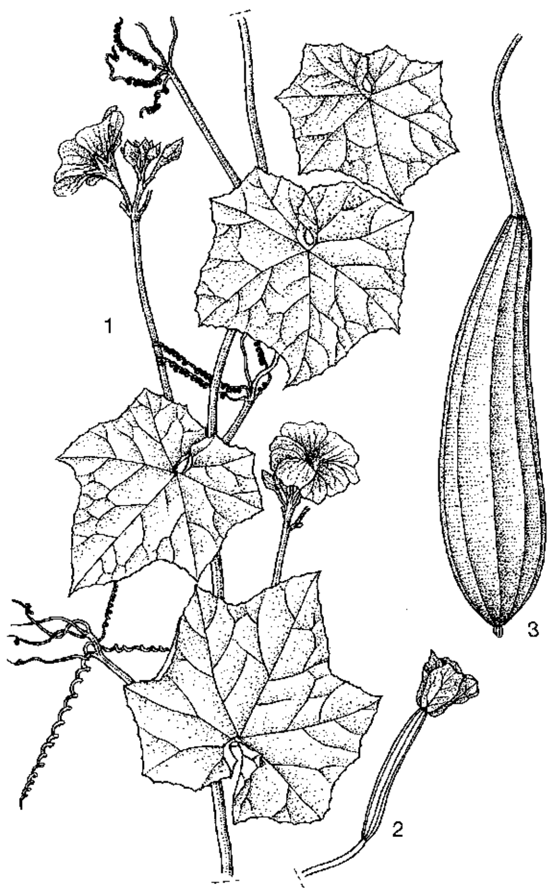
The amount of oil in *L. acutangula* seeds is 26% and the fatty acid composition is: linoleic acid 34%, oleic acid 24%, palmitic acid 23% and stearic acid 10%.

In *L. aegyptiaca* the seed kernels comprise 51% of the weight of the seeds and contain about 46% oil and 40% protein. The pure oil is colourless, odourless and tasteless and its fatty acid composition is: linoleic acid 42%, oleic acid 41%, palmitic acid 10% and stearic acid 7%.

The presence of glucosides and saponins in the fruits and of colocynthin in the seeds may explain their medicinal activity.

The 1000-seed weight is about 90 g.

Description Climbing annual monoecious (seldom dioecious) herbs with simple, palmately lobed leaves. Tendrils 2–6-fid. Male flowers racemose with 3 or 5 stamens that are often variously unit-



Luffa acutangula (L.) Roxburgh – 1, flowering shoot; 2, female flower; 3, fruit.

ed. Female flowers solitary, with 3 bilobed stigmas. Fruit a dry and fibrous capsule, dehiscent by an apical operculum, with a fibrous skeleton inside that is a spongy network. Seeds numerous, flattened.

- *L. acutangula*: Stem acutely 5-angled; tendrils hairy, 3-fid or more. Leaves 5–7-angled or shallowly lobed, 10–25 cm × 10–25 cm, scabrous, pale green. Peduncle of male flowers 15–35 cm long, female flowers borne in same leaf-axils as male flowers; flowers 4–5 cm in diameter, 5-merous, fragrant, pale yellow, opening in the evening; stamens appearing as 3, 2 double 2-thecous, 1 single 1-thecous. Fruit club-shaped, angled, 10-ribbed, 15–50 cm × 5–10 cm, crowned by enlarged calyx and style. Seed ellipsoid, 41–1.3 cm × 0.7–0.9 cm, pitted, black, without wing-like margin.
- *L. aegyptiaca*: Stem 5-angled, up to 15 m long;

tendrils 2–6-fid. Leaves broadly ovate to reniform, deeply 5–7-lobed, 6–25 cm × 8–27 cm, scabrous, cordate at base, dentate, apex acute, dark green; petiole 5–10 cm long, hairy. Male flowers 4–20 in 12–35 cm long racemes, female flowers borne in same leaf-axils as male flowers; flowers 5–10 cm in diameter, 5-merous, deep yellow, opening during the day; stamens 3 or 5. Fruit subcylindrical, smooth or not prominently ribbed, 30–60 cm long, crowned by enlarged calyx and style. Seed broadly ellipsoid, 1–1.5 cm long, smooth, black, with a narrow wing-like margin.

Growth and development Germination is epigeal and seedlings emerge 4–7 days after sowing. Depending on cultivar, ecological circumstances and cultural practices, flowering may start 6–10 weeks after sowing. Initially mainly male flowers are produced. The ratio of male to female flowers is high. It is possible to induce pistillate flowers by phytohormone sprayings, e.g. indole-acetic acid. In *L. acutangula* the flowers open in the evening and in *L. aegyptiaca* during the day. The stigmas remain receptive for 36–60 hours after anthesis. Normally, loofahs are cross-pollinated by a large number of insects.

Harvesting of fruits for vegetable use may start 9–13 weeks after sowing. Fruits take 4–5 months to attain full maturity. Fruits for vegetable use can be picked regularly during 4–5 months, but yield declines after 2–3 months of harvesting.

Other botanical information

In *L. acutangula* 3 groups are distinguished:

- cv. group Angled Loofah (synonym: var. *acutangula*), the large-fruited cultivated forms. In India cultivar 'Satputia' is hermaphrodite.
- var. *amara* (Roxb.) C.B. Clarke, a wild or feral form, confined to India with small, extremely bitter fruits.
- var. *forskalii* (Harms) Heiser & Schilling, a wild form confined to Yemen, but possibly developed from escapes of the cultivated forms.

In *L. aegyptiaca* 2 groups are distinguished:

- cv. group Smooth Loofah (synonym: var. *aegyptiaca*), the large-fruited, less bitter, cultivated forms, with different cultivars for the production of the best vegetable or the best sponge.
- var. *leiocarpa* (Naudin) Heiser & Schilling, the wild forms occurring from Burma to the Philippines, to north-eastern Australia and Tahiti.

There is still controversy about the correct botanical name of the smooth loofah. Here, *L. aegyptiaca* P. Miller is adopted, following the most cautious interpretation of available information. In the literature, *L. cylindrica* (L.) M.J. Roemer is mostly used.

Ecology Loofahs grow best in the low humid tropics, up to 500 m altitude. Although *L. aegyptiaca* is tropical in origin, excellent loofahs of adapted cultivars are grown during the summer season in Japan.

Both species are frost-sensitive. Too heavy rainfall during flowering and fruiting is harmful. In seasonal climates dry-season planting is more successful than wet-season planting. Daylength sensitivity differs per cultivar; there are day-neutral, short-day and long-day cultivars.

Loofahs prefer rich soils with high organic matter content, good drainage and pH values of 6.5–7.5. Sandy loams may be used if sufficient essential nutrients are supplied.

Propagation and planting Loofahs are propagated by seed. Sometimes seeds are soaked for 24 hours. For angled loofah, seeds are sown on mounds or ridges 75–100 cm apart, 45 cm between plants or 60–90 cm × 60–90 cm, 2–3 cm deep. For smooth loofah, distances of ridges or mounds are 75–90 cm apart, 45–60 cm between the plants or 90–120 cm × 90–120 cm. Seed rate for angled loofah is 3.5–5 kg/ha, for smooth loofah 2.5–3.5 kg/ha. Transplanting is sometimes practised.

Husbandry Smooth loofah is mostly grown as a sole crop by commercial growers, while angled loofah is especially important in home gardens and intercropped with other vegetables. Smooth loofah is always grown on strong supports, but angled loofah is sometimes allowed to trail on the ground. During dry conditions, irrigation at regular intervals is required. In some areas, hand pollination is recommended. Laterals are often pruned to stimulate early production of female flowers. Top pruning and partial leaf pruning also promotes flower and fruit development, resulting in higher fruit yield. NPK should be incorporated in the soil before planting, followed by an N fertilizer up to the period of fruit formation. High N under high temperatures promotes maleness in flowering. Normally, in smooth loofah the number of fruits is limited to 20–25 per plant.

Diseases and pests Loofah is not very sensitive to diseases and pests. Powdery mildew (*Erysiphe cichoracearum*), downy mildew (*Pseudoperonospora cubensis*) and fruit flies (*Dacus* spp.) may cause problems but are rarely serious.

Harvesting For use as a vegetable, young immature fruits are picked starting 12–15 days after fruit set. Maximum yield is obtained by harvesting the fruits as late as possible, i.e. when they are

about half the size of a mature fruit. Older fruits become bitter and fibrous and are inedible.
For use as a sponge, fruits of the smooth loofah are harvested when they are fully mature, which is indicated by yellowing of the base and apex, about 4–5 months after planting. When cut, part of the stalk is usually left on the fruit for convenience in handling.

Yield Each plant of *L. acutangula* may produce 15–20 fruits. Fruits for vegetable production may weigh 0.2–0.8 kg. *L. aegyptiaca* produces 20–25 fruits per plant, with a comparable weight. For vegetable production 8–12 t/ha of immature fruits is reasonable. With top pruning, the yield can be as high as 37 t/ha. In Japan yields of 60 000 matured fruits/ha of the smooth loofah (for sponge use) are reported, equivalent to 50 t/ha. Individual mature fruits weigh 0.5–2.5 kg. Crossings of the improved hermaphrodite cultivar 'Satputia' with a traditional cultivar gave five times more yield than both parents.

Handling after harvest Immature fruits of loofah are easily damaged. Careful wrapping and packaging is needed to enable long distance transport. Storage life of young fruits is 2–3 weeks at 12–16°C.
The best sponges are from mature but still green fruits of smooth loofah. They are processed by immersing in running water until the rind disintegrates. When the rind has disappeared, the pulp and seeds are washed out. The sponges are then bleached with hydrogen peroxide and dried in the sun.

Genetic resources Germplasm collections of loofah for vegetable use are kept in India (Vivekananda Parvatiyakrishi Anusandhan Shala, Almora, Uttar Pradesh), Nigeria (NACGRAB, Ibadan), the Philippines (NPGRL-IPB, Los Baños), Taiwan (Taiwan Agricultural Research Institute, Wufeng, Taichung), and the United States (SRPIS-USDA, Georgia). Germplasm collections of sponge loofah are kept in Japan.

Breeding Crossing experiments are easy to perform, because in most loofah cultivars and landraces the flowers are unisexual. Local cultivars and landraces are open-pollinated and hence populations are very variable. Such local populations are being collected in Malaysia, India and the Philippines for use in breeding programmes. High-yielding cultivars are available from seed companies in Thailand and Indonesia. In Japan and Taiwan, F_1 hybrids between angled and smooth loofah have been developed. These are very bitter and inedible but suitable for sponge production. Hybrids with other wild species are highly sterile.

Prospects Loofah is expected to assume more importance as a vegetable than it does now. Moreover, in the mature state it yields sponges, which are a useful renewable resource. Sponge production, combined with harvest of seeds as a source of protein and oil, might offer attractive prospects for South-East Asian countries.

Literature |1| Dutt, B. & Roy, R.P., 1990. Cytogenetics of the Old World species of Luffa. In: Bates, D.M., Robinson, R.W. & Jeffrey, C. (Editors): Biology and utilization of the Cucurbitaceae. Comstock, Cornell University Press, Syracuse, New York, United States. pp. 134–140. |2| Hamid, S., Salma, Sabir, A.W. & Khan, S.A., 1985. Cultivation conditions and physico-chemical properties of Luffa acutangula var. acutangula seed oil. Pakistan Journal of Scientific and Industrial Research 28(2): 119–122. |3| Heiser, C.B. & Schilling, E.E., 1990. The genus Luffa: a problem in phytogeography. In: Bates, D.M., Robinson, R.W. & Jeffrey, C. (Editors): Biology and utilization of the Cucurbitaceae. Comstock, Cornell University Press, Syracuse, New York, United States. pp. 120–133. |4| Martin, F.W., 1979. Vegetables for the hot, humid tropics. Part 4. Sponge and bottle gourds, Luffa and Lagenaria. Science and Education Administration, United States Department of Agriculture, New Orleans, United States. 21 pp. |5| Porterfield, W.M., 1955. Loofah: the sponge gourd. Economic Botany 9: 211–223. |6| Purseglove, J.W., 1968. Tropical Crops. Dicotyledons 2. Longman, London, United Kingdom. pp. 128–132. |7| Sahni, G.P., Singh, R.K. & Saha, B.C., 1987. Genotypic and phenotypic variability in ridge gourd. Indian Journal of Agricultural Sciences 57(9): 666–668. |8| Seshadri, V.S., 1985. Cucurbits. In: Bose, T.K. & Som, M.G. (Editors): Vegetable crops in India. Naya Prokash Press, Calcutta, India. pp. 91–164.

G.J. Jansen, B.H. Gildemacher
& L. Phuphathanaphong

Lycium chinense Miller

Gard. dict. ed. 8, n. 5 (1768).
SOLANACEAE
$2n = 24$

Synonyms *Lycium rhombifolium* (Moench) Dippel (1794).

Vernacular names Chinese boxthorn, Chinese matrimony vine, Chinese wolfberry (En). Lyciet (Fr). Indonesia: daun koki. Malaysia: kaukichai, kaukichoy, kei-chi. Thailand: kaokichai, kaochichai (Bangkok). Vietnam: c[aa]u kh[owr]i, kh[owr]i t[uwr], c[aa]u k[yr] t[uwr].

Origin and geographic distribution Chinese boxthorn is a native of China and Japan. It is occasionally cultivated and locally naturalized in other areas, e.g. in Hong Kong, Taiwan, Korea, Indo-China, southern Asia (Nepal), South-East Asia (Thailand, Malaysia, Indonesia), and West, Central and South Europe.

Uses Chinese boxthorn is mainly grown for the young shoots and leaves which are used as flavouring and as vegetable. They are added to soups or cooked with pork. Fresh and dried fruits are also used as a flavouring in speciality Chinese dishes.

In traditional medicine, especially in China, Chinese boxthorn is used variously: as an energy restoring tonic (tea from the leaves, wine from the berries), as an antifebrile and antirheumatic tonic (roots), as an aphrodisiac (seeds) and as a cure for a wide range of ailments from skin rashes and eyesight problems to diabetes.

It is also used as an ornamental plant, as a hedge plant (Indo-China, Europe) and as a bonsai plant in Japan.

Production and international trade Chinese boxthorn is most important in eastern Asia but no statistics are available. In Thailand, Indo-China, Malaysia (Cameron Highlands) and Indonesia (Dieng Plateau) it is grown locally, mainly for consumption by ethnic Chinese.

Properties Per 100 g edible portion the leaves contain: water 90 g, protein 3.9 g, fat 0.6 g, carbohydrates 3.9 g, fibre 1.3 g, ß-carotene 4.3 mg, vitamin B_1 0.08 mg, vitamin B_2 0.3 mg, niacin 0.8 mg, vitamin C 8 mg, Ca 142 mg, P 41 mg, Fe 5.2 mg, Na 184 mg and K 498 mg. The energy value is about 150 kJ/100 g.

Botany A deciduous shrub, 1–2 m tall, branches recurved or pendent, usually provided with a few straight spines. Leaves distichous, bright green, with a short petiole; leaf-blade lanceolate to ovate, 1–14 cm × 0.5–6 cm, usually widest below the middle, the lower ones largest, margin entire. Flowers solitary or in few-flowered racemes, erect; calyx campanulate, 5-toothed, 3 mm long; corolla funnel-shaped, 5-lobed, 10–15 mm long, tube narrowly cylindrical at the base for 1.5 mm, lobes 5–8 mm long, red-purple with yellowish throat; stamens 5, long-exserted, filaments with dense tuft of hairs at the base; ovary 2-locular, stigma 2-lobed. Fruit an ellipsoid berry, about 1 cm × 0.5–0.75 cm, red, many-seeded. Seed 3–4 mm in diameter.

Lycium chinense Miller – 1, leafy shoot; 2, flowering and fruiting shoot.

The flowers open in the morning and are cross-pollinated by insects (bees, flies, ants). In Thailand flowering is in June – September, fruiting in August – November. Cultivated plants normally last for about 10 years.

L. chinense is often confused with the closely related *L. barbarum* L. (synonyms: *L. halimifolium* Miller, *L. vulgare* Dunal), which is of similar origin and habit. *L. barbarum* has elliptical leaves, 2–10 cm × 0.6–3 cm, calyx 4 mm, corolla 9 mm long with tube narrowly cylindrical for 2.5–3 mm and lobes 4 mm long.

Ecology Chinese boxthorn is well adapted to a wide range of climatic conditions: annual rainfall may be as low as 300 mm but can be over 2000 mm as well, the temperature range is large. It grows from sea-level up to 2000 m altitude in the tropics. At low altitudes the plant flowers profusely but in the highlands (above 2000 m) it does not flower. It needs a sunny location and tolerates poor soils (sand and rocky soils). The pH range is 5–8.

Agronomy Chinese boxthorn can be propagated by seed but it is usually vegetatively propagated by hardwood cuttings of 15–20 cm length. Cut-

tings may be taken at any time and planted in situ at a spacing of 30 cm × 30–50 cm, about 5 cm deep. If planted for fruits, the spacing is usually wider, 40 cm × 120 cm. Plants frequently harvested respond very well to manure and fertilizers. Plants are kept at about 60 cm height.
In Korea, anthracnose caused by *Colletotrichum gloeosporioides* and *C. dematium* may cause complete necrosis of the fruits but does not seriously affect leaves and stems.
Harvesting of young shoots may start about two months after planting and be continued at 2-week intervals, but it is better to wait about one year. Soft young shoots of about 30 cm are required. Fruits are harvested when they turn orange-red, and are dried in the sun for 5–7 days. Young shoots and leaves wilt rapidly after harvest; they are sometimes stripped off the stems and kept wet. To be eaten as a vegetable they only need to be cooked for 3–4 minutes.

Genetic resources and breeding No germplasm collections of Chinese boxthorn are known to exist, but it is likely that some material is available in germplasm collections in China and Japan. In Korea, selection programmes have been carried out, starting from local landraces. Plants with dark green leaves appear to be more drought tolerant than plants with light green leaves.

Prospects Chinese boxthorn is an interesting vegetable and medicinal plant. It is easy to cultivate and nutritious. Research should concentrate on selection of high-yielding clones and optimization of cultural practices.

Literature |1| Larkcom, J., 1991. Oriental vegetables. The complete guide for garden and kitchen. John Murray, London, United Kingdom. pp. 67–69. |2| Seo, G.S., Lee, J.Y., Kim, S.Y., Kim, J.K. & Ahn, B.C., 1985. A study on cultural methods of boxthorn (Lycium chinense Mill.). Research Reports of the Rural Development Administration – Crops (Korea R.) 27(2): 218–224. |3| Seo, G.S., Lee, J.Y., Kim, S.Y., Kim, J.K. & Han, G.H., 1986. The effects of fertilizer application level and topdressing method on the yield component and fruit yield of Lycium chinense Mill. Korean Journal of Crop Science (Korea R.) 31(4): 465–469. |4| Stearn, W.T., 1972. Lycium L. In: Moore, D.M. (Editor): Solanaceae. Flora Europaea. Vol. 3. Cambridge University Press, United Kingdom. pp. 193–194.

Y. Paisooksantivatana

Lycopersicon esculentum Miller

Gard. Dict. ed. 8, n. 2 (1768).
SOLANACEAE
$2n = 24$

Synonyms *Solanum lycopersicum* L. (1753), *Lycopersicon lycopersicum* (L.) Karsten (1882).

Vernacular names Tomato, love apple (En). Tomate (Fr). Indonesia: tomat. Malaysia: tomato. Papua New Guinea: tamato. Philippines: kamatis (Tagalog), butinggan (Ilocano), ang-angseg (Bontoc). Cambodia: peeng pâh. Laos: khüa sômz. Thailand: makhua-thet (general), makhua-som (northern). Vietnam: c[af] chua.

Origin and geographic distribution Tomato originated from the Andean region of South America, in the area now covered by parts of Bolivia, Chile, Ecuador, Colombia and Peru. The related species of cultivated tomato are native and widely distributed in this region. Archaeological and circumstantial evidence (diversity of types and culinary uses, abundance of local names) all suggest that tomato was domesticated in Mexico, outside its centre of origin, and that the most likely ancestor is the primitive cherry tomato (*L. esculentum* var. *cerasiforme* (Dunal) Gray). Tomato was introduced into Europe in an already fairly advanced stage of domestication soon after the discovery of the New World. From there, it was taken to other parts of the world at various times: in the 17th Century to China, South and South-East Asia; and in the 18th Century to Japan and the United States. Although initially grown only as a curiosity in Europe because of its erroneous reputation as a poisonous fruit, tomato has now become one of the most important vegetables worldwide.

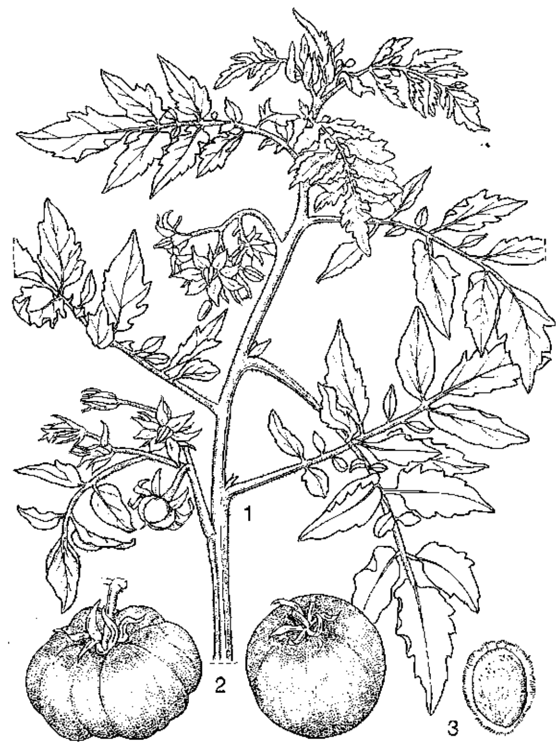
Uses Tomatoes are consumed fresh in salads, sauces and as a flavouring ingredient in soups and meat or fish dishes. Tomatoes can also be made into sweetened candies, dried fruits, and even into wine. The economically most important uses of tomatoes are, however, in various processed forms such as purées, juice, ketchup, canned whole and diced fruits. Although tomatoes generally rank low in comparative nutritional value, they outrank all other vegetables in total contribution to human nutrition because so much is consumed in so many different ways.

Production and international trade Total area of tomato planted annually worldwide is about 2.7 million ha, 80–85% in market gardens, producing an estimated 68 million t. Tomatoes are produced in the open field, under plastic shelter or in greenhouses, dependent on climate and season.

Leading tomato producing countries are: Commonwealth of Independent States (formerly Soviet Union) 400 000 ha, China 320 000 ha, United States 180 000 ha, Egypt 140 000 ha, Italy 140 000 ha, Turkey 120 000 ha, India 83 000, Romania 80 000 ha, Spain 60 000 ha and Brazil 50 000 ha. Most of the world trade in tomatoes comes in processed products from the Mediterranean region, the United States and South and Central America. In Indonesia 75% of all market garden tomatoes (29 000 ha) is grown above 400 m altitude. The area used for tomato production in the Philippines is about 18000 ha, in Thailand 8300 ha and in Malaysia 700 ha.

Properties 100 g of edible fruit portion contains approximately the following: water 94 g, protein 1.0 g, fat 0.2 g, carbohydrates 3.6 g, Ca 10 mg, Fe 0.6 mg, Mg 10 mg, P 16 mg, vitamin A 1700 IU, vitamin B_1 0.1 mg, vitamin B_2 0.02 mg, niacin 0.6 mg, and vitamin C 21 mg. The energy value is 80 kJ per 100 g. As may be noted, tomatoes are a good source of vitamins A and C. Both vitamins increase in quantity when the fruits are allowed to ripen on the vine. Immature fruits contain the alkaloid tomatine. The seeds contain 24% of a semi-drying edible oil. The 1000-seed weight is 2.5–3.5 g.

Description Variable annual herb, up to 2 m tall or taller. Taproot strong, to 0.5 m deep or more, often damaged at transplanting, and a dense system of lateral and adventitious roots. Stem solid, coarsely hairy and glandular. Growth habit varies from indeterminate with stems several m long and prostrate when not supported, carrying an inflorescence every 3rd to 4th leaf, to determinate with several short and more erect stems with inflorescences (4–6 per stem) every second leaf and one terminating the shoot apex. Leaves spirally arranged with a 2/5 phyllotaxy, imparipinnate, in outline 15–50 cm × 10–30 cm; petiole 3–6 cm long; major pinnae 7–9, opposite or alternate, ovate to oblong, 5–10 cm long, irregularly toothed and sometimes pinnatifid at base; a variable number of smaller pinnae occur between the larger leaflets; leaflets petiolate, covered with (glandular) hairs, producing a characteristic and species-specific odour. Inflorescence cymose, normally with 6–12 flowers, but compound inflorescences with 30–100 flowers do occur; flowers regular, about 2 cm in diameter, pendent, bisexual, hypogynous, usually 6-merous; calyx tube short and green with pointed lobes, persistent and enlarging in fruit; corolla rotate, petals yellow, stellate, later reflexed and dropping off after pollination; stamens 6, anthers bright yellow, conically arranged, surrounding the style and prolonged into a sterile beak; superior ovary with 2–9 loculi and fleshy central placenta. Fruit a berry, flattened, globular or oblate, smooth or furrowed, 2–15 cm in diameter, green and hairy when young, glabrous and shiny, red, pink, orange or yellow when ripe. Seed flattened ovoid, 3–5 mm × 2–4 mm, up to 250 per fruit, light brown and hairy. Germination is epigeal. Seedlings have a thin taproot and cordate cotyledons; the first leaves have few leaflets.



Lycopersicon esculentum Miller – 1, flowering and fruiting shoot; 2, fruit types; 3, seed.

Growth and development Dry seed (5.5% moisture content) will maintain a high viability (90–95% germination) after several years of storage at ambient (18–24°C) temperatures, provided the seeds have been extracted from fully mature fruits. Seeds germinate within 6 days after sowing at optimum soil temperatures of 20–25°C, and the first true leaf is formed one week later. About 7–11 leaves are usually formed on the main stem before the apex is transformed into a terminal inflorescence. The main axis is continued by the development of a new stem from the primary axillary bud in the leaf subtending the inflorescence.

As the new shoot grows this leaf changes to a position above the inflorescence. The appearance is of continuous growth with internodal inflorescences, but it is actually sympodial. In indeterminate cultivars this process is repeated indefinitely with inflorescences every 3rd to 4th leaf and fruits maturing sequentially over a long period of time. In determinate types it is arrested after 4–6 inflorescences, when the primary axillary bud of the last leaf aborts and the next bud develops into a slower growing shoot with one leaf and a terminal inflorescence. Strong axillary bud development at the base of determinate plant types produces the bushy habit with several stems and a short period of prolific flowering followed by a period when fruit growth is dominant. In processing tomatoes, synchronization of fruit growth and ripening is such that once-over machine harvesting becomes possible.

The first flowering starts under optimum conditions about 5–7 weeks after sowing. *L. esculentum* is a moderately cross-pollinated species in origin, but most cultivars have become almost exclusively self-pollinated. Bees and bumble bees are the most important pollinating agents and are also increasingly used in glasshouses to stimulate pollen dehiscence.

Pollen tube growth is slow and fertilization takes place 50–55 hours after pollination. Fruits are mature 6–8 weeks later. Adequate seed set is necessary for normal fruit development, but parthenocarpic fruit set occurs in some types, or can be induced by growth regulators.

The duration to peak harvest (50% of the crop) depends on cultivar and season. In the cool season: 90–110 days after transplanting; during the hot season: 60–90 days after transplanting. Fruits may range in weight from 20 g for cherry tomatoes to as much as 300 g in some large-fruited fresh market cultivars. Each fruit contains numerous seeds embedded in its locules, ranging from 50–80 in the cherry tomatoes to as many as 250 in fresh market cultivars.

Other botanical information The genus *Lycopersicon* Miller comprises a relatively small number of species and is variously subdivided in literature. A much followed approach is that of Rick, who recognizes two complexes:

- the esculentum complex, including *L. esculentum*, *L. hirsutum* Humb. & Bonpl., *L. pimpinellifolium* (Jusl.) Miller, *L. chmielewskii* Rick, Kes., Fob. & Holle, *L. parviflorum* Rick, Kes., Fob. & Holle, *L. pennellii* (Corr.) D'Arcy, and *L. cheesmanii* Riley;
- the peruvianum complex, including *L. peruvianum* (L.) Miller, and *L. chilense* Dunal.

All species are closely interrelated and native to western South America; they intercross quite easily. *L. esculentum* can be hybridized with all other species with varying degrees of difficulty.

Within *L. esculentum*, two botanical varieties are distinguished:

- var. *cerasiforme* (Dunal) Gray, with fruits 1.5–3 cm in diameter;
- var. *esculentum*, with fruits > 3 cm in diameter.

Numerous cultivars of tomato exist. They can be variously classified, e.g. according to:

- growth habit: indeterminate, semi-determinate and determinate (bush);
- fruit size: small round (cherry, 30 g; 'Moneymaker', 80 g), medium-large round (120–150 g), beefsteak and ribbed (> 200 g);
- fruit shape: round, egg-shaped and elongated ('San Marzano') or flat ('Marmande');
- colour: red, pink, orange or yellow;
- utilization: for fresh market (direct consumption) or processing (high dry matter content and viscosity).

In South-East Asia, many farmers still use local cultivars (landraces). For example in West Java, 'Gondol' is a popular highland tomato, possibly derived from a very ancient import of 'San Marzano' and reputed for a good taste and a certain tolerance of late blight and other diseases. This cultivar has been replaced by Taiwanese hybrids which, in spite of an inferior taste, have become popular because of the high yield capacity combined with resistance to transport damage. The Indonesian cultivars 'Ratna', 'Intan' and 'Berlian', selected from AVRDC lines with bacterial wilt resistance, have found some acceptance at lower elevations. The Thai cultivars 'Seeda' and 'Seedathip' are well adapted to the rainy season. It may be expected that in the coming decade landraces and local open-pollinated cultivars will be replaced by F_1 hybrid cultivars.

Ecology Ideally, tomato requires a relatively cool, dry climate for high yield and premium quality. However, it is adapted to a wide range of climatic conditions. Tomatoes have been grown as far north as the Arctic circle (under protection) down to the hot and humid equator. The optimum temperature range for growth and development is 21–24°C. Prolonged exposure to temperatures below 12°C can cause chilling injury. Mean temperatures above 27°C severely impair growth and fruit set. Destruction of pollen and egg cells occurs when the maximum daytime temperature is 38°C or above for 5–10 days. Fruit set is also generally poor if the night temperatures are above 21°C during the few days before and after anthesis. Hot dry winds can also cause flower abortion. Light intensities below 1000 ft-candles retard plant growth and delay flowering. Tomatoes are not sensitive to daylength and set fruits in photoperiods ranging from 7–19 hours.

Tomatoes can be grown in many soil types ranging from sandy loam to clay-loam soils that are rich in organic matter. The ideal soil pH range is 6.0–6.5; higher or lower pHs can cause mineral deficiencies or toxicities. Long periods of flooding are detrimental to tomato growth and development.

Propagation and planting Tomatoes can be direct-seeded or transplanted in the field. Relatively little seed-drilling or direct sowing into the field is practised in the humid tropics because of adverse growing conditions. In contrast, raising the young transplants in a special nursery enables growers to achieve great seedling uniformity and to check for early diseases and pests. Other advantages of transplanting are the smaller quantity of seed needed and reduced competition of weeds in the field. For raising transplants, 70–90 g of seeds are sown per 250 m^2 of seed-bed, which is sufficient to provide enough plants for one ha. Many farmers use banana leaf pots for plant raising. When direct-seeded, the sowing rate is about 500–1000 g of seeds per ha. Fertilizer at the rate of 40 g ammonium sulphate, 50 g superphosphate, 30 g potassium chloride and 2 kg compost per 1 m^2 of seed-bed area should be broadcast and worked into the seed-bed.

The young seedlings require sufficient water to sustain good, healthy growth. A week before transplanting, watering should be reduced to harden the seedlings. Three- to four-week-old seedlings (15–25 cm high with 3–5 true leaves) are ready for transplanting. Seedlings must be thoroughly watered 12–14 hours before they are lifted out of the seed-bed, to avoid excessive damage to the roots. Transplanting should be done in the afternoon or on a still, cloudy day to reduce the transplanting shock, and should be followed by watering. Spacing between plants and distance between rows depends on the cultivar's growth habit and whether the plants are to be supported by stakes or left to grow on the ground. Common configurations are plants spaced 30–60 cm apart in single rows on 1.0–1.4 m wide beds, while in some cases, a double-row bed system is used.

Husbandry Fertilizers for tomatoes should be fairly rich in phosphorus. Excess nitrogen is associated with fruit puffiness and blossom-end rot and generally causes excessive vegetative growth. Amount and timing of fertilizer applications vary with soil types and cultivars. The following general recommendation (kg/ha basis) can be used as a guide: 60 N, 80 P_2O_5, 60 K_2O and 10 Borax for basal application; one week after transplanting for determinate, and 3 weeks after transplanting for indeterminate types, 60 N and 60 K_2O as side dressing; at 3–5 weeks after transplanting, another 60 N and 60 K_2O as side dressing.

Pruning the lateral shoots of staked indeterminate cultivars is often practised, to produce fruits of good and uniform size. Only one or two stems may be allowed to grow, depending on local practice. The number of fruits per cluster as well as the number of clusters may also be regulated. No pruning and regulation of fruit number and clusters are normally practised on determinate cultivars. Semi-determinate cultivars may be grown either as a determinate or indeterminate crop.

Tomatoes need adequate irrigation during the early plant growth, fruit set and fruit enlargement stages. About 2 cm of water per week is needed under cool conditions; about 7 cm during hot and dry periods. Consistency of water supply to the plants plays a major role in attaining uniform maturity. It also reduces the incidence of blossom-end rot, a physiological disorder normally attributed to calcium deficiency during fruit enlargement.

Competition with weeds, especially in the hot and humid tropics, can be very severe. To control weeds, a pre-emergence herbicide may be applied onto the field beds before transplanting, supplemented by manual weeding and mulching the beds with rice straw.

Diseases and pests Tomatoes are attacked by many diseases and insect pests. Of about 60 pathogens that attack tomatoes, 15 are considered to be major diseases in the hot and humid tropics. Bacterial wilt (*Pseudomonas solanacearum*) has often been reported as the most serious handicap for tomato in the tropics. Bacterial spot (*Xanthomonas campestris* p.v. *vesicatoria*) is another serious disease. Long-term crop rotation is recommended to control bacterial wilt. There is no effective chemical control. Minimal infection has been reported when tomatoes are grown after lowland paddy rice. The most important control measures are a good drainage, a large dose of organic manure, and mulching in order to avoid rain damage to the roots. Bacterial spot is serious during the rainy season and is most noticeable on fruits but also causes damage to the foliage and stems. It is transmitted through the seed. Spraying with copper fungicides can control this disease fairly well except under heavy infection. Growing resistant cultivars is the best control method for both bacterial diseases but resistance is not universal owing to variable strains of the pathogens.

The most important fungal diseases of tomatoes in the tropics are early blight (*Alternaria solani*), black leaf mould (*Pseudocercospora fuligena*), late blight (*Phytophthora infestans*), leaf mould (*Cladosporium fulvum*, syn. *Fulvia fulvum*), powdery mildew (*Leveillula taurica*), southern blight (*Sclerotium rolfsii*) and target spot (*Corynespora casiicola*). Diseases such as *Fusarium* wilt (*F. oxysporum*) and *Verticillium* wilt (*V. dahliae*) are reported sporadically in the tropical highlands but they are not a problem elsewhere in the tropics. Some fungal diseases like late blight can cause 100% yield loss in the highland tropics where conditions are cool and moist. Spraying with chemicals such as maneb compounds can control most of the above fungal diseases in varying degrees. Field sanitation and proper rotation are also effective control measures. Planting resistant cultivars is the most effective and the cheapest control method, but resistance to late blight is not yet available. Local cultivars often are more or less tolerant of late blight.

Important virus diseases are tomato mosaic, cucumber mosaic, tomato yellow leaf curl, tomato yellow dwarf, and more recently also tomato spotted wilt virus. Depending on the virus, transmission is through direct contact and through insect vectors such as aphids, whitefly and thrips. Early control of the insect vectors and general field sanitation can serve well to control the virus diseases, but resistant cultivars, once available, will be the most effective control method.

Among the insects, the polyphagous tomato fruitworm (*Heliothis armigera*) is one of the most destructive, causing as high as 70% yield loss due to fruit boring. Synthetic pyrethroids sprayed at the rate of 50–100 g a.i. per ha can control this pest. Tomatoes should not be planted near other alternative hosts like maize and cotton.

Cotton aphid (*Aphis gossypii*) is a major pest during the dry season. It injures the plants by sucking the sap and by acting as a vector for the cucumber mosaic virus. Spraying with dimethoate and prothiophos is effective to control aphids. Several species of coccinelid beetles and syrphids also act as natural enemies, but they generally appear when the aphid population is already high. Whitefly (*Bemisia tabaci*) is a serious pest, not only because of its foraging on the tomato plants but also because it acts as a vector of the tomato yellow leaf curl virus. More recently thrips, especially *Frankiniella occidentalis*, has become a problem as it is the vector for tomato spotted wilt virus.

Root knot nematodes (*Meloidogyne incognita* and other species) invade the tomato roots and cause galling. Yield losses due to direct infection and indirect losses due to predisposition or breakdown of resistance to other root diseases, such as bacterial wilt, are significant. Nematicides and other soil fumigants can effectively control nematodes but are expensive. The use of resistant cultivars is still the most cost-effective measure, although breakdown of resistance can occur at high temperatures and there is no resistance to *M. hapla*.

Harvesting Fresh-market tomatoes are often harvested at the mature-green stage and ripened in transit or in storage before they are marketed. Generally, tomatoes harvested at pre-ripe stages tend to have lower quality (i.e. lower soluble solids, ascorbic acid and reducing sugars) than vine-ripened tomatoes. The nature of the growth and ripening pattern of fresh-market tomato cultivars requires frequent pickings for either mature-green or vine-ripe fruits.

In contrast to the fresh-market or table tomatoes, processing tomatoes are picked fully ripe. In developed countries, harvesting is often by machine. Tomatoes used for pureed products such as soup, juice, and sauce, are left on the vine until over 85% of the fruits are ripe. Those for whole tomatoes are picked while still firm, but often only 65% of the crop may be ready to pick all at once. Growers sometimes spray the crop with ethephon to accelerate the rate of ripening, thereby increasing the percentage that can be harvested at one time.

Yield The world's average tomato yield was 25 t/ha in 1989. This relatively high average yield is largely due to the extremely high tomato productivity under glasshouse culture in European countries (e.g. 420 t/ha in the Netherlands). Regionally, the average yields (t/ha) in 1989 were: Africa 18; North and Central America 37; South America 28; Asia 19; Europe 38; and Oceania 35. Average productivity in South-East Asia (Indonesia, Malaysia, the Philippines and Thailand) is still rather low at 8–12 t/ha. Seed yields are 100–150 kg/ha for hybrids and up to 300 kg/ha for open-pollinated cultivars.

Handling after harvest After picking, tomatoes may be moved to a shady place either in the field or at home to prepare them for the market.

Properly sorted and graded fruits generally command a better market price than ungraded fruits. The marketable fruits are then packaged in suitable containers, often 20-kg wooden boxes, bamboo baskets, plastic boxes, or other locally available packaging materials. Protection from injury is the chief benefit of proper packaging; it also reduces water loss although this is not generally a serious problem with tomatoes.

The storage life of tomatoes depends on the maturity stage at which they were harvested and on the desired quality of fruits. Quality is highest when completely ripe, whether artificially or on the vine. Ideally mature-green tomatoes should be stored for 7–10 days at 13–18°C with 85–90% relative humidity so that they will ripen properly. Ethylene is sometimes used to rapidly and uniformly ripen mature-green tomatoes prior to shipping them to the market, but this adversely affects quality.

Colour is the single most important visual parameter of tomato quality. Lycopene development at temperatures above 30°C is generally poor. This is the main reason that tomatoes grown in the hot tropics tend to have a pale red or yellowish colour and are poorly flavoured.

Genetic resources Many institutional collections of cultivated and wild *Lycopersicon* species exist throughout the world. Some of these collections have been well described, evaluated and documented for use by tomato scientists worldwide, the most important being the Tomato Genetic Stock Centre at the University of California, Davis, California (United States). A large collection is maintained at the Asian Vegetable Research and Development Center (AVRDC) in Taiwan. Since modern improved cultivars are rapidly replacing the old landraces, the latter should be collected for future breeding purposes.

Breeding Tomato is one of the best-studied plant species, reflecting its great economic importance. Many important genetic traits have been discovered, evaluated and genetically localized in their respective chromosomes. Tomato has a prolifically marked genome, very useful in genetic and breeding research. Many useful traits have been incorporated by tomato breeders into modern-day cultivars, among which are high yield, disease resistance, improved quality for processing, and stress tolerance. Seeds of both standard (open-pollinated) and F_1 hybrid cultivars are now available to tomato growers. New cultivars continue to be developed, offering improvements in one or more traits of interest. When tested in the South-East Asian countries the 'international' hybrid cultivars often show disadvantages and weaknesses, which can only be amended by breeding work 'in situ'. Areas of continuing concern to tomato breeders in South-East Asia are disease resistance (bacterial wilt, *Phytophthora* and *Alternaria*), tolerance to environmental stress (such as high temperatures, excess soil moisture due to high rainfall and problem soils, e.g. acid or saline soils), quality (for fresh-market consumption and for processing), and long shelf life (for long distance transport and longevity in storage).

Prospects Tomato scientists have accomplished a great deal in the past, including improvements in yield, disease resistance, adaptability to machine harvest, processing quality, tolerance of environmental stress, and others. However, more improvements need to be bred into modern-day cultivars. Fortunately, the vast reservoir of genetic variability in the genus *Lycopersicon* has been barely exploited. Conventional breeding techniques are still expected to be the mainstay of most future improvement programmes. However, the use of biotechnological techniques is rapidly gaining momentum and their impacts are potentially revolutionary. When integrated into existing plant breeding programmes, some of these techniques, such as DNA markers, allow plant breeders to access, transfer and combine genes at a rate, precision and genomic range never before possible with conventional breeding. Indeed, the prospects for further improving the tomato industry through advances in genetic and production techniques are bright.

Literature |1| Atherton, J.G. & Rudich, J., 1986. The tomato crop. Chapman & Hall, London/New York, United Kingdon/United States. 661 pp. |2| Divinagracia, C.N. & Villareal R.L., 1971. Tomato production in the Philippines. Department of Agricultural Communication, University of the Philippines, College of Agriculture. College, Laguna, the Philippines. 38 pp. |3| Gould, W.A., 1983. Tomato production, processing and quality evaluation. Avi Publishing Company, Westport, Connecticut, United States. 445 pp. |4| Kuo, C.G. & Lai, S.H., 1979. Suggested cultural practices for tomato. International Cooperator's Guide. AVRDC 79–127. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. 3 pp. |5| Opeña, R.T., 1985. Development of tomato and Chinese cabbage cultivars adapted to the hot, humid tropics. Acta Horticulturae 153: 421–436. |6| Opeña, R.T., Kuo, G.C. & Yoon, J.Y., 1987. Breeding for stress tolerance under tropical conditions in tomato and heading Chinese cabbage. In: Chang, W.N., MacGregor, P.W. & Petersen, J.B. (Editors): Improved vegetable production in Asia. ASPAC-FFTC, Taiwan. pp. 88–109. |7| Opeña, R.T., Green, S.K., Talekar, N.S. & Chen, J.T., 1990. Genetic improvement of tomato adaptability to the tropics. In: Green, S.K. & McLean, B.M. (Editors): Tomato and pepper production in the tropics. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. 619 pp. |8| Rick, C.M., 1978. The tomato. Scientific American 239: 76–87. |9| Villareal, R.L., 1980. Tomatoes in the tropics. IADS Development-Oriented Literature Series. Westview Press, Boulder, Colorado, United States. 174 pp. |10| World Information Center for Tomato Processing Industry, 1989. Tomato News. Bernard Bieche Consultant. Avignon Cedex, France. No 7. 23 pp.

R.T. Opeña & H.A.M. van der Vossen

Melientha suavis Pierre

Bull. Soc. Linn. Paris 1: 763 (1888).

OPILIACEAE

$2n$ = unknown

Synonyms *Melientha acuminata* Merrill (1926).

Vernacular names Melientha (En). Malaysia: tangal (Sabah). Philippines: malatado (Mindanao). Cambodia: daam prec. Laos: hvaan. Thailand: phakwan-pa. Vietnam: rau s[aws]ng, rau ng[os]t r[uwf]ng.

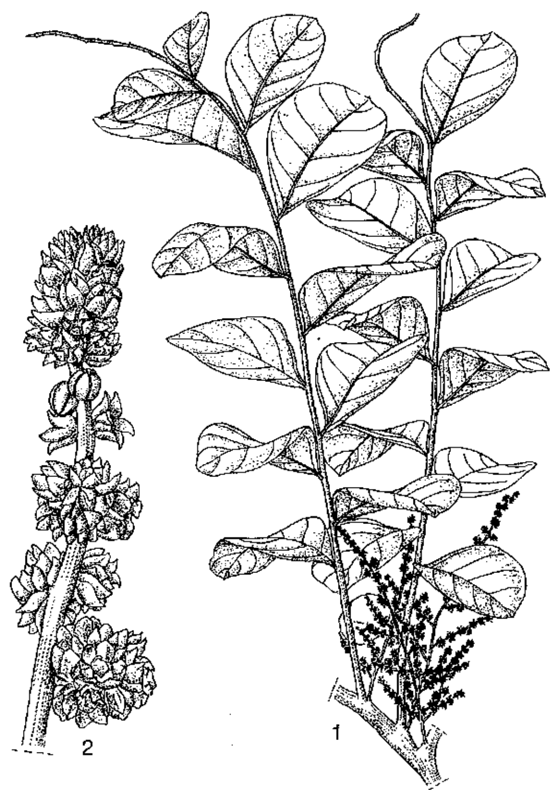
Origin and geographic distribution *M. suavis* is native to Thailand, Peninsular Malaysia, Laos, Cambodia, Vietnam, Sabah and the Philippines. Throughout this area it occurs wild and occasionally in cultivation. The species is rare in Malaysia and the Philippines.

Uses The young shoots, leaves, inflorescences and young fruits are widely consumed as a vegetable after boiling. The ripe fruits are also edible (juicy mesocarp) and in Vietnam the seeds are eaten in the same way as groundnut after boiling or frying. The wood is often used for charcoal in Thailand.

Production and international trade *M. suavis* is used and marketed locally. Cultivation on a commercial scale is known from northern Thailand, where intercropping in fruit orchards is practised. For this purpose, seedlings can be obtained from commercial nurseries in the area.

Properties *M. suavis* is a good source of protein and vitamin C. Fresh shoots and leaves contain per 100 g edible portion: water 76.6 g, protein 8.2 g, carbohydrates 10.0 g, fibre 3.4 g, ash 1.8 g, carotene 1.6 mg, vitamin C 115 mg. The energy value is about 300 kJ/100 g.

Botany Small evergreen dioecious tree up to 13 m tall with usually cylindrical crown and glabrous, drooping branchlets. Leaves simple, alternate, glabrous, coriaceous-fleshy; petiole up to 5 mm long; leaf-blade lanceolate, elliptical to ovate or obovate, (4–)6–12(–16) cm × 2.5–5(–7) cm, apex obtuse- or retuse-mucronulate, sometimes acute to acuminate, base cuneate-attenuate; nerves 5–6(–8) pairs. Inflorescence panicle-like, irregularly branched, mostly in groups on swellings at the main trunk but also on branches and even in the axils of the uppermost leaves; main rachis up to 15 cm, in fruiting state up to 20 cm long; flowers unisexual, 4- or 5-merous. Male flowers sessile, solitary or in groups of 3–5 (mainly at the end of the rachises) in the axil of a minute bract; tepals reflexed; filaments very short, attached to the base of the tepals; anthers relatively large; disk lobes fleshy, as large as the rudimentary



Melientha suavis Pierre – 1, flowering shoot; 2, top of inflorescence.

ovary. Female flowers solitary per bract, sometimes in groups of 3–4; pedicel 3–7 mm long; tepals adjacent to the ovary; the small staminodes alternating with broad disk lobes. Fruit a drupe, ellipsoid to slightly ovoid or obovoid, 2.3–4 cm × 1.5–2 cm, yellow; pericarp thin, 1.5–2 mm thick, with fleshy-juicy mesocarp and woody endocarp. Seed single, embryo with 3–4 linear cotyledons embedded in oily endosperm.

The genus *Melientha* Pierre is monotypic. Two subspecies are distinguished, differing by the form and the size of the fruits: ellipsoid, 2.3–3 cm long in ssp. *suavis;* obovoid, 3.5–4 cm long in ssp. *macrocarpa* Hiepko. The latter has only been observed in Sabah (Mt. Kinabalu).

The flowers are strongly fragrant. Without flowers or fruits, *M. suavis* is difficult to identify and consequently leaves of vegetatively similar species of Opiliaceae are sometimes eaten as a vegetable. If leaves of *Urobotrya siamensis* Hiepko, a species widespread in the same habitat as *M. suavis* in Thailand and Indo-China, are eaten, these may cause death by poisoning (its fruits are bright red and up to 1 cm long).

Ecology *M. suavis* occurs naturally in deciduous forest, rarely in dry evergreen forest (valleys, borders of streams), at altitudes of 300–900 (–1500) m. In Vietnam it is common on limestone soils, in Sabah on black rocky soils. Flowering is from December to March and fruiting from April to August. Pollination is by insects. Natural dispersal takes place by birds, water and wild animals.

Agronomy Propagation is by seed. Young shoots, leaves and inflorescences are usually collected from wild trees. Cutting off old branches will encourage the development of lateral shoots and new leaves. There is no information on diseases or pests. After harvesting, shoots or leaves are tied into bundles, which may be wrapped in a banana leaf to avoid wilting. They should be consumed within one or two days after harvesting. Yield data are not known.

Genetic resources and breeding Only natural stands are available for selection work as no germplasm collections exist.

Prospects Nutritionally *M. suavis* is an excellent vegetable. It deserves to be studied in more detail to determine its potential for wider use and cultivation in agroforestry systems.

Literature |**1**| Gagnepain, F., 1911. Opiliaceae. Melientha. In: Gagnepain, F. (Editor): Flore Générale de l'Indo-Chine [General flora of Indo-China]. Vol. 1. Masson, Paris, France. pp. 802–803. |**2**| Hiepko, P., 1979. A revision of Opiliaceae 1. Genera of the eastern Old World, excluding Opilia. Willdenowia 9: 13–56. |**3**| Hiepko, P., 1984. Opiliaceae. Melientha. In: van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 10. Kluwer Academic Publishers, Dordrecht, the Netherlands. pp. 38–40. |**4**| Pierre, L., 1892. Flore forestière de la Cochinchine [Forest flora of Cochinchina]. Fasc. 17. Paris, France. Fig. 264.

Nguyen Tien Hiep

Momordica L.

Sp. pl.: 1009 (1753); Gen. pl. ed. 5: 440 (1754).

CUCURBITACEAE

x = 7, 11, 14; $2n$ = 14 (*M. cochinchinensis*); $2n$ = 22 (*M. charantia*)

Major species and synonyms

- *Momordica charantia* L., Sp. pl.: 1009 (1753), synonyms: *M. indica* L. (1754), *M. elegans* Salisb. (1796), *M. chinensis* Sprengel (1893).
- *Momordica cochinchinensis* (Loureiro) Sprengel, Syst. veg. 3: 14 (1826), synonyms: *Muricia cochinchinensis* Loureiro (1790), *Momordica mixta* Roxburgh (1832).
- *Momordica subangulata* Blume, Bijdr.: 928 (1826), synonym: *M. eberhardtii* Gagnepain (1918).

Vernacular names

- *M. charantia*: Bitter gourd, bitter cucumber, balsam pear (En). Paroka (Fr). Indonesia: paria, pare (Javanese). Malaysia: peria, peria laut, periok. Philippines: ampalaya (Tagalog), paria (Ilocano), palia (Bisaya). Cambodia: mreah. Laos: haix, s'aix. Thailand: mara (general), phakha (north-eastern), maha (northern). Vietnam: m[uw][ows]p d[aws]ng (north), kh[oor] qua (south).
- *M. cochinchinensis*: Sweet gourd, spiny bitter cucumber, giant spine gourd (En). Indonesia: pupia, torobuk, toropu (Moluccas). Malaysia: teruah. Philippines: buyok-buyok (Tagalog), paruk-paruk (Ilocano), taboguak (Bicol). Cambodia: makkao. Laos: khaawz. Thailand: fakkhao (central), phak-khao (northern), khikakhrua (southern). Vietnam: d[aa]y g[aas]c.
- *M. subangulata*: Indonesia, Malaysia: kamas. Thailand: phakmae (southern).

Origin and geographic distribution The genus *Momordica* belongs entirely to the Old World. It comprises about 45 species, mainly occurring in Africa and 5–7 species in Asia; a few

species have been introduced into the New World tropics.
M. charantia was possibly domesticated first in eastern India and southern China. It now has a pantropical distribution, with wild and cultivated populations. It is thought that it came from Africa to Brazil with the slave trade and that bird dispersal of the seeds accounts for its spread within continents. It is the most important cultivated *Momordica* species. *M. cochinchinensis* occurs wild and cultivated from India to Japan and throughout Malesia. It has not been reported from Java. *M. subangulata* is only known from the wild and is distributed in Thailand, Indo-China, Peninsular Malaysia and Java.

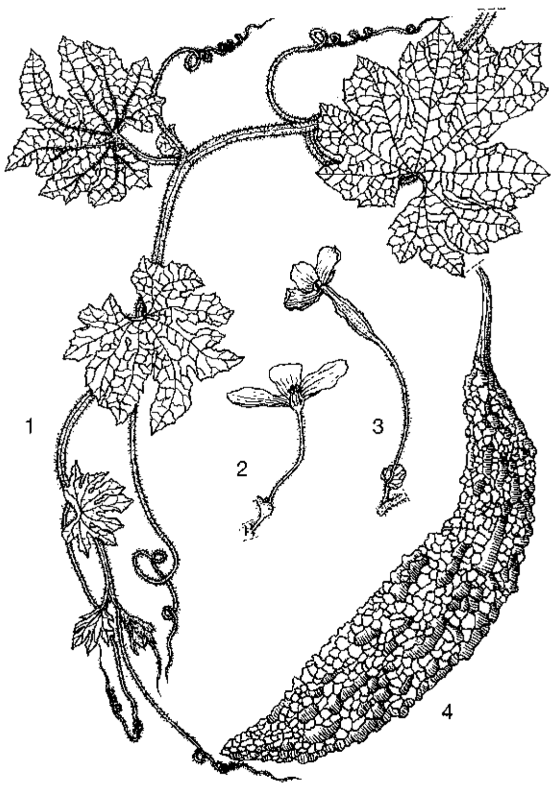
Uses The immature fruits of *M. charantia* are the main vegetable product; they are prepared in many ways. Fruits, young shoots and flowers are used as flavouring, the leaves as a leafy vegetable (popular in the Philippines) and the pulpy arils as a sweet. Bitter gourd may be canned, pickled or dehydrated. To reduce the bitter taste, the fruits can be blanched or soaked in salt water before cooking. Bitter gourd has numerous medicinal uses. In folk medicine it is used to treat diabetes; ripening fruits contain inhibitory compounds which affect glucose metabolism. Juice from various plant parts is used externally to treat skin disorders and is ingested to cure arthritis, rheumatism and asthma. Most plant parts act as a purgative when ingested. There are reports about abortifacient properties of seed extracts. Occasionally, *M. charantia* is planted as an ornamental.
Immature fruits, young leaves and flowers of *M. cochinchinensis* are similarly used as a vegetable. The seeds contain an oil which is used as an illuminant in Indo-China. Its roots froth in water and may be used as soap. The seeds are used in folk medicine for several diseases, e.g. a paste is applied to treat warts, abscesses and ulcers.
Young shoots and immature fruits of *M. subangulata* can be eaten as a vegetable, but they are not very popular.

Production and international trade Bitter gourd is mainly cultivated in South-East Asia and India. In the Philippines it ranks second to squash in total hectarage (4600 ha) among the traditional cucurbits; average annual production is estimated at 17000 t. On a worldwide basis, exact statistics are lacking. The other *Momordica* species are only important for the local market.

Properties The edible portion of bitter gourd fruits is about 95%. Per 100 g edible portion it contains: water 83–92 g, protein 1.5–2 g, fat 0.2–1 g, carbohydrates 4–10.5 g, fibre 0.8–1.7 g. The energy value is 105–250 kJ/100 g. Compared with other Cucurbitaceae it is high in minerals and vitamins: Ca 20–23 mg, Fe 1.8–2 mg, P 38–70 mg, vitamin C 88–96 mg. Per 100 g edible portion the leaves contain: water 82–86 g, protein 2.3 g, fat 0.1 g, carbohydrates 17 g, fibre 0.8 g. They are an excellent source of iron and calcium and a good source of phosphorus and vitamin B.
Per 100 g edible portion sweet gourd fruits contain approximately: water 90 g, protein 0.6 g, fat 0.1 g, carbohydrates 6.4 g, fibre 1.6 g, minerals 0.9 g. The energy value is 120 kJ/100 g. It is low in vitamins.
Bitterness in *M. charantia* is attributed to the non-toxic alkaloid momordicine. The fruit contains the hypoglycemic principle charantin. The ripe fruit and the leaves have been found to contain a guanylate cyclase inhibitor which has the ability to impair chemical carcinogen-induced increases in guanylate cyclase activity.
Eleostearic acid is the dominant fatty acid in the oil of the seeds of *M. charantia* and *M. cochinchinensis* (50–65%).
The 1000-seed weight of bitter gourd (*M. charantia*) is about 60 g.

Description Monoecious or dioecious, annual or perennial herbs, with climbing or trailing stems. Tendrils simple or bifid, one at each node, positioned as a stipule. Leaves alternate, simple or 3–15-foliolate, petiolate. Male flowers solitary, umbellate or in short racemes or fascicled, often subtended by a conspicuous bract; calyx tubular with 5 lobes; petals 5, free; stamens 3, 2 double 2-thecous, 1 single 1-thecous. Female flowers solitary; perianth usually similar as in male flowers; stigma 3-lobed. Fruit a berry (pepo), ovoid-ellipsoid to elongate-fusiform, fleshy, ornamented with tubercles, spines, wings or ridges, indehiscent or often dehiscent by 3 valves and exposing the seeds enveloped in scarlet pulp. Seeds usually compressed, with sculptured testa and grooved margins.

- *M. charantia*. Monoecious, annual, up to 5 m long. Stem 5-ridged. Tendrils simple. Leaves simple, pellucidly dotted, palmately veined; petiole 1–7 cm long; leaf-blade broadly ovate-reniform or suborbicular in outline, 2.5–10 cm × 3–12.5 cm, cordate at base, deeply palmately (3–)5(–9)-lobed, lobes obovate and sinuate-lobulate or sinuate-toothed. Flowers axillary, solitary, about 3 cm in diameter, yellow; peduncle 0.5–3 cm (male), 0.2–5 cm (female) long, bearing an apical bract up to 2 cm (male), 1 cm (female)



Momordica charantia L. – *1, leafy shoot; 2, male flower (longitudinal section); 3, female flower (longitudinal section); 4, fruit.*

in diameter; pedicel 2–5.5 cm (male), 1–10 cm (female) long. Fruit 3–11(–45) cm × 2–4(–8) cm, irregularly warty, orange, dehiscing from apex downwards to the base into 3 valves. Seed 8–16 mm × 4–10 mm × 2.5–3.5 mm, brown.

- *M. cochinchinensis*. Dioecious, perennial, starting from a tuberous root, often climbing high in trees. Stem robust, angular. Tendrils simple, robust. Leaves simple, palmately veined; petiole 5–10 cm long, with 2–5 glands near the middle; leaf-blade suborbicular in outline, 12–20 cm in diameter, cordate and with some glands at base, deeply 3(–5)-lobed, lobes subovate with entire or subdentate margins. Flowers axillary, solitary, about 8 cm in diameter, yellow, but blackish at base inside. Male flowers with peduncle 5–30 cm long, bearing an apical, suborbicular, sessile bract, 3–4 cm × 4–5 cm; pedicel 3–10 mm long. Female flowers with much smaller bract situated near the middle of the peduncle; pedicel 3–10 mm long. Fruit 10–20 cm × 6–10 cm, yellow, turning red at maturity, densely covered with small tubercles. Seed 2.5 cm × 2 cm × 0.5 cm, brown.
- *M. subangulata*. Dioecious, perennial, with annual vines. Stem angular. Tendrils simple, rather short. Leaves simple, thin, palmately 3–5-veined; petiole 2–5 cm long; leaf-blade ovate-reniform, 6–13 cm × 4–9 cm, sometimes 3–5-lobed, cordate at base, margins denticulate. Flowers axillary, solitary, up to 5 cm in diameter, yellow. Male flowers with peduncle up to 10 cm long, bearing an apical, reniform bract, 1–2 cm long; pedicel 1–3 mm long; calyx lobes ovate, emarginate at apex. Female flowers with peduncle 6–7 cm long, bearing a small bract at the base. Fruit ovoid, 6–7 cm × 3–4 cm, densely covered with longitudinal wings. Seed 1 cm × 1 cm × 0.5 cm, grey.

Growth and development Emergence of bitter gourd takes 5–7 days after sowing. Wild types may exhibit some kind of seed dormancy and germinate after 15–20 days. Within two weeks rapid vine elongation takes place, followed by growth of lateral stems. Apical dominance is not common. Under optimal conditions, flowering starts 45–55 days from sowing. Flowering continues throughout the cropping season, which usually lasts up to 6 months. Flower opening starts early in the morning; however, low temperature may delay flower opening and shedding by about one hour. Anthers dehisce about two hours before anthesis and optimum viability of pollen and receptivity of the stigma are attained at anthesis. Flowers are cross-pollinated by insects, especially bees. For vegetable use the green fruits can be harvested about 2 weeks after anthesis. Fruits left on the vine turn orange or yellow and dehisce some 25–30 days after anthesis. Removal of fruits before ripening permits continued fruiting and prolongs crop duration.

Seeds of *M. cochinchinensis* germinate very unevenly. Flowering starts 2 months after planting and continues for 6–8 months. At higher latitudes plants remain dormant in winter and start growing again from the tuberous root in spring.

Other botanical information The wild and cultivated forms of *M. charantia* have been variously classified (cultivated: ssp. *charantia* or var. *charantia*; wild: ssp. *abbreviata* (Ser.) Grebensc. or var. *abbreviata* Ser.). The cultivated forms can better be classified in cultivar groups and cultivars, but there is no good classification system. A provisional solution has been proposed for India and South-East Asia, in which cultivated *M. charantia* is divided into 2 groups: fruits with diameter less than 5 cm (var. *minima* Williams & Ng) and fruits with diameter larger than 5 cm (var. *maxima* Williams & Ng). In var. *minima* all fruits are green and the seed is 13–14.5 mm × 6.8–8.5 mm; cultivars fall into 3 groups: short fruited (6–7.5 cm), medium fruited (8–12 cm) and long fruited (12–22 cm). In var. *maxima* the fruits are white or green and the seed is 14.8 mm × 8.5 mm; cultivars fall into 2 groups: medium fruited (12–17 cm) with white fruits, and long fruited (about 20 cm) with green fruits. The system is rather artificial; cv. group names and cultivar names, as well as voucher specimens, are lacking.

Popular cultivars of bitter gourd in the Philippines are the OP's 'Sta Rita' and 'Makiling' and their F_1 hybrids 'Jade Star A' and 'Jade Star B'.

M. charantia seems to be closely related to *M. balsamina* L., a pantropical species of dry areas, whose leaves and fruits are also edible. Its occurrence and position in South-East Asia are not clear. *M. dioica* Roxb. ex Willd., a species with edible fruits, occurring from India to Burma, closely resembles *M. subangulata,* which is often confused with it. *M. dioica* has echinulate fruits, in *M. subangulata* the fruits are longitudinally alate.

Ecology

- *M. charantia* grows well in tropical and subtropical climates. It is adapted to a wide range of environments and can be grown year-round. The plant is sensitive to waterlogging. It tolerates a wide range of soils but it thrives in a well-drained sandy loam, rich in organic matter. It grows wild in lowland rain forest and riverine forest, up to 1000 m altitude.
- *M. cochinchinensis* prefers a warm humid climate with temperatures ranging from 20–35°C and an average rainfall of 1500–2500 mm. It fruits mainly in the rainy season. The plants stay dormant during the dry, cool season. Sweet gourd grows well in fertile, well-drained sandy loam soils with pH near neutral. In the wild it can often be found in open places on lowland riverbanks.
- *M. subangulata* prefers disturbed areas, but its ecological requirements are unknown.

Propagation and planting *M. charantia* is propagated by seed. Direct seeding is most common, but transplanting may be done if seeds are scarce. The use of pre-germinated seed results in an even establishment. Seeds are sown in the field at a spacing of 30–50 cm between hills and 2–3 m between rows. Optimum plant density differs per cultivar, but ranges from 6500–11000 plants per ha. In some areas closer spacings are used, 50 cm × 50 cm, resulting in 40000 plants/ha.

M. cochinchinensis is mainly propagated by its tuberous roots. Since it is dioecious, tubers from male and female plants should be planted together. A male population of 8–10% should be maintained to ensure proper pollination. About 50000 sprouted tubers per ha are required. When started from seed, about 3–5 kg/ha of seed is needed.

To control weeds, soil preparation should be started 4–6 weeks before planting.

Husbandry Not much research has been done on cultural practices, but in general these are comparable with those of cucumber (*Cucumis sativus* L.). The use of compost (10 t/ha) together with chemical fertilizer is recommended, e.g. 40 kg N, 30 kg P and 30 kg K. Half the nitrogen is usually applied as a side dressing during flowering. Supplementary irrigation, preferably furrow irrigation, is necessary to maintain a good crop in the dry season. Bitter gourd is almost always trellised, especially in the wet season. Overhead trellises are also needed. Trellising should be done before the vines are 1 m long.

Diseases and pests Diseases of bitter gourd, especially *Cercospora* leaf spot and downy mildew (*Pseudoperonospora cubensis*), may have a drastic effect on yield if not controlled. Bacterial wilt (*Pseudomonas solanacearum*) also attacks the crop, as do root knot nematodes (*Meloidogyne incognita*).

Fruit fly (*Dacus cucurbitae*) is the most destructive insect pest of bitter gourd. Chemical sprays are not effective, because adult female fruit flies only lay eggs on growing fruits and do not feed on them. Sanitation practices like burying and burning of infested fruits are recommended to prevent build-up of the pest population. *Epilachna* beetles, caterpillars (*Spodoptera litura, Heliothis armigera*), aphids and mites also attack the crop.

Chemical control of these diseases and pests should be done as a last resort. The most toxic pesticides should be avoided, because of possible harm to pollinators. Light traps and poison baits are sometimes used against fruit fly, using a sex attractant like hydrolysate 0.5 kg + 1.25 kg of 50% malathion wp + 200 g of molasses. Many growers protect young fruits with paper bags against fruit fly.

In *M. cochinchinensis* no serious diseases have been recorded, but *Epilachna* beetle and fruit fly may be serious pests.

Harvesting Bitter gourd requires much attention at harvest time. It usually takes 15–20 days after fruit set to reach a marketable stage. Delaying harvesting for 3–4 days leads to loss of fruit lustre and acceptability. Fruits are best harvested by cutting the fruit stalk with scissors or a sharp knife. Fruits of *M. cochinchinensis* are harvested when they are almost mature.

Yield A yield of 20–30 t/ha is considered satisfactory for *M. charantia*. The number of fruits per plant may reach 20–25 during the cropping period. Some F_1 hybrids yield up to 40 t/ha. *M. cochinchinensis* may yield 30–60 fruits per plant, each weighing 1–3 kg.

Handling after harvest Fruits of bitter gourd do not keep well and should be sent immediately to the market. Damaged and deformed fruits are removed. Fruits are arranged in bamboo baskets layered with newspapers or banana leaves, and can then be kept for 2–3 days. If stored at 4°C, fruits can be kept for 3 weeks.

Genetic resources The world collection of *Momordica* germplasm is held at NBPGR, New Delhi, India. In South-East Asia, collections are available in the Philippines (NPGRL-IPB, Los Baños) and in Thailand (Department of Horticulture, Kasetsart University, Bangkok). Elsewhere, collections are held in several institutes in India, South Africa, Taiwan and the United States.

Breeding Breeding work on bitter gourd is geared towards developing cultivars with superior quality (i.e. less bitter fruits), a high female to male ratio, high yield, and resistance to diseases and pests. Resistance to foliar diseases and fruit fly is important. The wild forms of bitter gourd are potential sources for resistance. The exploitation of hybrid vigour in this crop is well documented. In many South-East Asian countries, commercial F_1 hybrids often twice as productive as the traditional open-pollinated cultivars, have been released.

Prospects In South-East Asia bitter gourd will remain an important vegetable crop although production is expected to remain small-scale. Breeding for less bitterness will increase the crop's popularity. The potential and limitations of *M. cochinchinensis, M. subangulata* and other wild *Momordica* species need further investigation.

Literature |**1**| Keraudren-Aymonin, M., 1975. Cucurbitacées. Momordica. In: Flore du Cambodge, du Laos et du Vietnam [Flora of Cambodia, Laos and Vietnam]. Vol. 15. Muséum National d'Histoire Naturelle, Laboratoire de Phanérogamie, Paris, France. pp. 36–44. |**2**| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 205–208. |**3**| Seshadri, V.S., 1986. Cucurbits. In: Bose, T.K. & Som, M.G. (Editors): Vegetable crops in India. Naya Prokash Press, Calcutta, India. pp. 91–164. |**4**| Shadeque, A. & Baruah, G.K.S., 1984. Sweet gourd: a popular vegetable of Assam. Indian Farming 34(8): 25–35. |**5**| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 179–181. |**6**| Walters, T.W. & Decker-Walters, D.S., 1988. Balsam-pear (Momordica charantia, Cucurbitaceae). Notes on economic plants. Economic Botany 42: 286–288. |**7**| Williams, J.T. & Ng, N.O., 1976. Variation within Momordica charantia L., the bitter gourd (Cucurbitaceae). Annales Bogorienses 6(2): 111–123.

M.E.C. Reyes, B.H. Gildemacher & G.J. Jansen

Monochoria K.B. Presl

Reliq. haenk. 1: 127 (1827).

PONTEDERIACEAE

No basic chromosome number (x) exists. All species show a complex of polyploidy with associated aneuploidy. The most common numbers are $2n = 28$ for *M. hastata* and $2n = 52$ for *M. vaginalis*.

Major species and synonyms

- *Monochoria hastata* (L.) Solms-Laubach, in: A. DC., Monogr. phan. 4: 523 (1883), synonyms: *Pontederia hastata* L. (1753), *Monochoria hastaefolia* K.B. Presl (1827).
- *Monochoria vaginalis* (N.L. Burman) Kunth, Enum. plant. 4: 134 (1843), synonyms: *Pontederia vaginalis* N.L. Burman (1768), *P. pauciflora* Blume (1827), *Gomphima vaginalis* (N.L. Burman) Rafinesque (1837).

Vernacular names

- *M. hastata*: hastate-leaved pondweed, arrow-leaved monochoria (En). Indonesia: eceng gede, bia-bia, wewehan. Malaysia: chacha layar, kangkong air. Papua New Guinea: maoa. Philippines: gabi-gabihan (Tagalog), kasal-kasal, payaw-payaw (Bisaya). Cambodia: chrach. Laos: 'ii hin. Thailand: phaktop-thai, phaktop (central), phakpong (central). Vietnam: rau m[as]c.
- *M. vaginalis*: oval-leaved pondweed, oval-leaved monochoria, pickerel weed (En). Indonesia: eceng padi, eceng leutik, wewehan. Malaysia: kelayar, keladi agak. Philippines: biga-bigaan (Tagalog), gabing uwak (Tagalog), bilagut (Ilocano). Cambodia: chrach. Thailand: khakhiat, ninlabon (central), phakhin (north-eastern). Vietnam: rau ch[os]c, rau m[as]c l[as] thon.

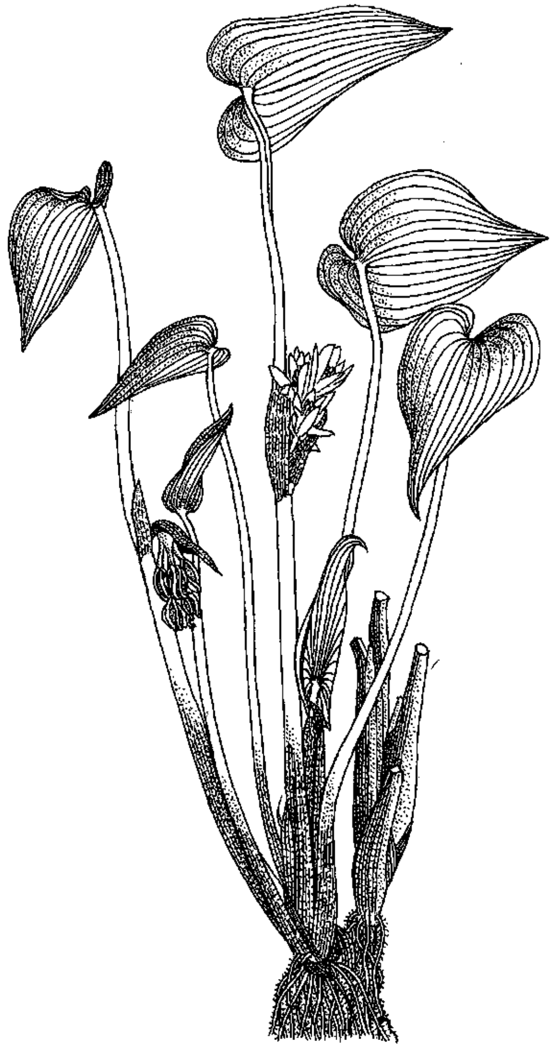
Origin and geographic distribution *Monochoria* is a small genus comprising 8 species, all native in the warmer parts of the Old World (2 in Africa, 4 in Asia, 2 in Australia). *M. hastata* is native in tropical South and South-East Asia extending to northern Australia. *M. vaginalis* is native in South Asia, throughout South-East Asia, extending also to China, Japan, Fiji islands and northern Australia. It has become naturalized in Hawaii, California and in rice fields in Russia and Italy. It is sometimes cultivated as a vegetable.

Uses In southern and eastern Asia *M. vaginalis* and to a lesser degree *M. hastata* are eaten as vegetables. Usually the leaves and stems are cooked but in South-East Asia the inflorescences are sometimes eaten raw. In the Philippines (Luzon) rhizomes of *M. vaginalis* are said to be eaten, but *M. vaginalis* is rarely rhizomatous. The rhizomes of *M. hastata* are cooked for cattle feed in Sulawesi (Indonesia). Both species have also medicinal applications. The pulverized rhizome of *M. hastata* is applied to relieve itching. The leaves of *M. vaginalis* pounded and mixed with turmeric (*Curcuma longa* L.) and *Portulaca pilosa* L. are applied to boils after they have burst. The juice of the roots is used to treat stomach and liver disturbances and also to cure asthma and toothache. The juice of the leaves is used for curing coughs. Sometimes *Monochoria* species are planted as ornamentals.

Production and international trade Both pondweed species are occasionally sold in local markets in Indonesia, Malaysia and Thailand, but production data are not recorded.

Properties The following composition per 100 g edible portion has been reported for *M. vaginalis*: water 88.6 g, protein 1.0 g, fat 0.2 g, carbohydrates 3.8 g, vitamin A 1000 IU, vitamin B_1 0.08 mg, vitamin C 30 mg, Ca 80 mg, P 45 mg, and Fe 3.7 mg. The energy value is 75 kJ/100 g.

Description Erect, ascending or occasionally creeping, emergent or floating annual or perennial herbs, growing in fresh water, glabrous. Stems sometimes rhizomatous, roots adventitious, fibrous. Leaves radical, simple, with long petioles. Inflorescences terminal, few- or many-flowered, paniculate, raceme- or umbel-like, borne above or below the leaves on naked, elongated, unbranched inflorescence stalks which terminate with 2 opposed spathes; the lower spathe (bract) leaf-like with sheath, petiole and blade; the upper spathe (bracteole) enclosed within the lower one at anthesis or exposed; the lower spathe often so dominant that the inflorescence appears to burst out of a normal-looking petiole; flowers bisexual, showy, withering within one day; perianth of 6 tepals, free, blue to white with green midribs, persistent in fruit; stamens 6; ovary 3-celled, stigma entire or lobed. Fruit a loculicidal capsule, ellipsoidal to subglobular, many seeded. Seed cylindrical to ovoid or subglobular with 8–14 longitudinal ribs or wings, brown to black.



Monochoria vaginalis (N.L. Burman) Kunth – flowering plant.

- *M. hastata*. Rhizomatous perennial with strong and robust stems, 30 cm or more long, up to 2 cm in diameter; petiole up to 90 cm long, bright red below; leaf-blade sagittate to hastate, up to 20 cm × 15 cm. Inflorescence sub-umbellate, (10–)20–30(–60)-flowered, appearing to burst out of a normal-looking petiole, peduncle up to 65 cm long; lower spathe with sheath 3–8 cm long, petiole 3–12 cm long, blade sagittate or hastate, 7–18 cm × 4–14 cm; upper spathe without petiole and blade, membranous, up to 5 cm long; pedicel up to 3 cm long; tepals 10–18 mm × 7–8 mm, twisted around the fruit; stamens 6, 5 yellow, 1 blue; style 5–6 mm long. Fruit ovoid, 12 mm × 9 mm. Seed ovoid, ca. 1 mm × 0.5 mm, 10-ribbed.

- *M. vaginalis*. Annual, rarely rhizomatous, stems creeping or ascending. Petiole up to 50 cm long; leaf-blade linear or lanceolate to ovate, 2–21 cm × 0.2–10 cm. Inflorescence very variable, with (1–)2–7(–20) flowers becoming strongly deflexed in fruit; peduncle 2–50 cm long; lower spathe with sheath 1–3.7 cm long, petiole 0.5–7 cm, blade linear or lanceolate to ovate or cordate, 1.3–10 cm × 0.3–15 cm; upper spathe 1–3.5 cm long; pedicel up to 3 cm long; tepals 8–15 mm × 8 mm; stamens 6, 5 yellow, 1 blue; style 2–5 mm long. Fruit ellipsoidal to ovoid, 0.8–1.2 mm × 0.4–0.7 mm. Seed ovoid, 0.5–1 mm × 0.3–6 mm with 8–10 narrow wings.

Growth and development

- *M. hastata* can attain a height of up to 2–3 m during the rains, adjusting its height to the rise of the water level. Inflorescence and leaf-blades are always borne above the water level. Anthesis takes place in the morning. Flowers are self-compatible and largely self-pollinated. The seeds take 10–15 days to develop. Germination takes place under water, but dispersal is mostly by fragmentation of the rhizome. The plants usually grow in clumps. In the subtropics the above-ground parts die off in winter.
- *M. vaginalis* is extremely variable in height, from 3 cm to over 50 cm. It is usually annual but in permanent water may persist for more than one year. There is no particular flowering period; it flowers as long as the habitat remains wet and the competition with other species is not too strong. Anthesis takes place in the morning, at midday the flowers wither. After fertilization the young infructescence bends downwards and the fruits often develop under water. The capsules are liberated as units. Seeds germinate under water. Large robust plants (in water) tend to have inflorescences bearing 7 or more flowers, while small, terrestrial plants may have only 1 or 2 flowers. Under stress conditions the leaf-blades tend to be linear or lanceolate, normally they are ovate.

Ecology Both species grow in sweet water swamps, along ditches, in shallow pools, on canal banks, and particularly in flooded rice fields where the plants are often the commonest weeds. *M. vaginalis*, the most common of the two species, occurs from the plains up to 1500 m, whereas *M. hastata* occurs up to 700 m altitude. *M. vaginalis* is commonest in eutrophic water, but may be found also in brackish and oligotrophic water. It is a stress-tolerant ruderal.

Agronomy Cultivation is hardly practised, but advantage is taken of naturally occurring populations. Both species can be propagated by seed, but more easily by partition, taking off lateral shoots. However, this is hardly necessary in localities where pondweed already occurs, because both species multiply spontaneously. They are typical weeds in irrigated rice. When the fields dry out, pondweed dies off completely, but new plants develop readily from seeds in the following inundation period. In constantly swampy localities, both species can reach old age and may attain large dimensions. At high population densities, pondweed is competitive and can reduce rice yields considerably.

Genetic resources and breeding No germplasm collections or breeding programmes exist.

Prospects Intensification of rice cultivation, in particular the use of herbicides, reduces the incidence of weedy companions such as pondweed. It would be worthwhile to try out controlled cultivation as a sole crop or in combination with similar vegetable crops such as *Limnocharis flava* (L.) Buchenau, possibly in an integrated pisciculture system.

Literature |1| Backer, C.A., 1951. Pontederiaceae. In: van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 4. Noordhoff-Kolff, Djakarta, Indonesia. pp. 255–259. |2| Boonkird, K., 1975. Pontederiaceae. Thai Forest Bulletin (Botany) 9: 12–13. |3| Cook, C.D.K., 1989. Taxonomic revision of Monochoria (Pontederiaceae). In: Tan, K. (Editor): The Davis & Hedge Festschrift. University Press, Edinburgh, United Kingdom. pp. 149–184. |4| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 612–614. |5| Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G., 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. pp. 486–489.

T. Boonkerd, B. Na Songkhla & W. Thephuttee

Moringa oleifera Lamk

Encycl. 1: 398 (1785).
MORINGACEAE
$2n = 28$

Synonyms *Guilandina moringa* L. (1753), *Moringa pterygosperma* Gaertner (1791), *M. polygona* DC. (1825).

Vernacular names Horseradish tree, drumstick tree, West Indian Ben (En). Ben ailé (Fr). Indonesia: kelor, marunga (Timor). Malaysia: meringgai, gemunggai. Philippines: malunggay (Tagalog). Burma: dandalonbin. Cambodia: mrum'. Laos: 'ii h'um. Thailand: marum (general), phakihum (north-eastern), makhonkom (northern). Vietnam: ch[uf]m ng[aas]y.

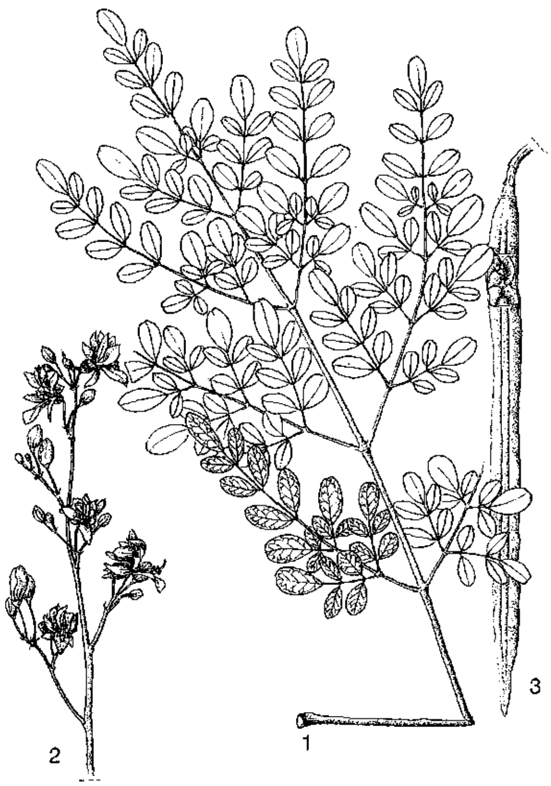
Origin and geographic distribution *Moringa oleifera* is indigenous and found growing wild in northern India and Pakistan. It was introduced into South-East Asia at an early date, and is now cultivated throughout the tropics. In many places it also occurs more or less naturalized.

Uses The horseradish tree has multiple uses, but in South-East Asia it is primarily used as a vegetable. The young fruits are a good substitute for yardlong bean (*Vigna unguiculata* (L.) Walp. cv. group Sesquipedalis), often used in curries. Stewed fruits cannot be eaten whole, but one sucks their contents and throws away the tough valves. The leaves and flowers are eaten as a cooked vegetable or put in soups. Fried seeds taste like groundnuts. The leaves and twigs are sometimes used as fodder. An edible oil (ben oil) can be extracted from the seeds; it is also useful for illumination, cosmetics and lubrication. The remaining seed cake is not very suitable as cattle feed because it contains a toxic alkaloid. The bark yields a coarse fibre suitable for making mats, paper and cordage. The stem yields a gum used in calico printing. Stems are also used as raw material for the production of α-cellulose pulps for the cellophane and textile industries. The root bark has the pungent taste of the true horseradish (*Armoracia rusticana* Gaertner, Mey. & Scherb.) and is used similarly as a condiment or garnish. Almost all parts of the tree, in particular the leaves and root bark, have medicinal applications (e.g. as diureticum, rubefacient, disinfectant). The horseradish tree is extensively cultivated as a living fence, as a shade tree in home gardens, and as a support for pepper vines. In Sudan, the protein-rich seeds are used as a low-cost water purifier (flocculant), highly valuable for sanitary improvements in remote villages of the Third World.

Production and international trade No commercial plantings of the horseradish tree have ever been established in South-East Asia. Trees are usually planted in home gardens or to mark boundaries. The fruits are a common product in local markets, especially in Thailand, but production figures have never been recorded.

Properties The edible portion of marketable fruits is about 83%. Per 100 g edible portion they contain: water 87 g, protein 2.5 g, fat 0.1 g, carbohydrates 3.7 g, ash 2.0 g, fibre 4.8 g, vitamin A 184 IU, vitamin B_1 0.05 mg, vitamin B_2 0.07 mg, niacin 0.2 mg, vitamin C 120 mg, Ca 30 mg, P 110 mg and Fe 5.3 mg. The energy value is 109 kJ/100 g.
The leaves are very rich in vitamin A and calcium. The edible portion amounts to 75% of marketable shoots. Per 100 g edible portion the leaves contain: water 75 g, protein 6.7 g, fat 1.7 g, carbohydrates 13.4 g, ash 2.3 g, fibre 0.9 g, vitamin A 11300 IU, vitamin B_1 0.06 mg, vitamin B_2 0.05 mg, niacin 0.8 mg, vitamin C 220 mg, Ca 440 mg, P 70 mg, Fe 7 mg. The energy value is 385 kJ/100 g.
Ben oil or Moringa oil, extractable from the seed (content ca. 25%), mainly consists of triglicerids of the fatty acid behen ($C_{22}H_{44}O_2$). Formerly it was considered a high quality oil, highly valued as lubricant for fine instruments and highly esteemed by perfumers for its great power of absorbing and retaining even the most volatile odours. At present the qualities of the oil are questioned. The antibiotic properties of the seed are due to the presence of the active principle 4α-L-rhamnosyloxy-benzyl-isothiocyanate. Exudation of gum is promoted by insects damaging the stem. The wood of the horseradish tree is soft and of no value.

Description Fast-growing, much-branched, often crooked tree or shrub, 3–10 m tall, stem 10–30 cm in diameter; bark corky, whitish, grey or pale buff, containing coarse fibre and exuding white gum when wounded; roots tuberous with pungent bark; young shoots purplish or greenish-white, usually puberulous. Leaves 2–3-pinnate, up to 60 cm long with 4–6 pairs of pinnae, articulated and soon falling, somewhat crowded towards the twig-ends; petiole 4–15 cm long, petiolule 1–6 mm; leaflets 6–11, elliptical or obovate, 0.5–3 cm × 0.3–2 cm, glabrous or puberulous. Inflorescence an erect to spreading panicle, 8–30 cm long with numerous white to creamy, fragrant flowers; pedicel 1–2 cm long, articulated near the top; calyx tubular, 5-lobed, green; petals 5, oblong-spathulate, 1–2 cm long, unequal, the largest erect, the others reflexed; stamens 5, staminodes 3–5, both hairy at base; ovary on a 2–3 mm long gynophore, densely



Moringa oleifera Lamk – 1, leaf; 2, inflorescence; 3, fruit.

hairy; style tubular with open canal, truncate at apex. Fruit a 3-angled, dagger-shaped, pendant capsule, 10–50 cm × 1.5–2.5 cm, green at first, later brown, glabrous, each valve 3-ribbed. Seed subglobose, trigonous, the body 1–1.4 cm in diameter, the 3 thin wings 0.5–2.5 cm long.

Growth and development Flowering occurs throughout the year with a maximum from May to July in Indonesia, and from January to February in Indo-China. The flowers are visited by 'honey-suckers', small birds hunting for insects or spiders. Unripe fruits are harvestable as vegetable 55–70 days after flowering, ripe fruits with mature seeds are harvestable 100–115 days after flowering. *M. oleifera* is a deciduous tree, but is seldom completely leafless. It is an excellent shade tree if not too heavy shade is required.

Other botanical information A number of forms are distinguished in Thailand, based on the size and the shape of the fruits. In the Philippines, two forms are distinguished, based on tree size: the native or giant type, and the Japanese or dwarf type. In Indonesia, forms occur which rarely flower and which are principally cultivated for their foliage.

Ecology The horseradish tree is strictly a tropical plant and grows well at lower elevations, both under wet and seasonal conditions, but can be found up to 1300 m altitude. It can be grown in various soils but thrives best in fertile, well-drained sandy loams.

Agronomy The horseradish tree can be propagated by seed but is usually propagated by cuttings. Seeds germinate within a week, and seedling trees flower after about 2 years. Cuttings, even if large, root readily and grow to sizeable trees within a few months and start bearing within one year of planting. Shield budding has been found to be successful in India. The horseradish tree is planted at a spacing of 3–5 m either way. It usually receives little care apart from watering during initial growth. In order to get good growth and high fruit yield, it is recommended to apply organic fertilizer during the first year, and inorganic nitrogen fertilizer once or twice a year. Horseradish tree tolerates drought very well, but supplementary irrigation during a long dry season is beneficial. Old and weak branches are pruned out to promote regrowth and regulate the tree shape.

The main insect pests are aphids, mites and insects that eat the fruit wall, but the extent of damage has never been evaluated.

Yields are low during the first two years, but from the third year onwards, individual tree yields of 600 or more fruits can be obtained for a period of 10–15 years. A production of 2150 fruits with a total fresh weight of 190 kg in one main harvest on a 21/2-year-old tree has been reported from Thailand.

Genetic resources and breeding Considerable genetic variability is available in north-western India. No breeding programmes are currently in progress.

Prospects *M. oleifera* is certainly underexploited at the moment. Its numerous uses (vegetable, seed oil, fibre, shade, hedge, ornamental, medicine), its easy propagation and its pantropical cultivation justify more intensive research into its biological and economic possibilities.

Literature |**1**| Mahajan, S. & Sharma, Y.K., 1984. Production of rayon grade pulp from Moringa oleifera Lam. Indian Forester, March 1984: 303–306. |**2**| Polprasid, P., 1991. Marum [Horseradish tree]. Kasikorn 64(2): 163–167. |**3**| Ramachandran, C., Peter, K.V. & Gopalakrishnan, P.K., 1980. Drumstick (Moringa oleifera): a multipurpose Indian vegetable. Economic Botany 34(3): 276–283. |4| van Steenis, C.G.G.J., 1949. Moringacease. In: van Steenis. C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 4. Noordhoff-Kolff, Djakarta, Indonesia. pp. 45–46. |5| Vidal, J., 1962. Moringacées. In: Flore du Cambodge, du Laos et du Vietnam [Flora of Cambodia, Laos and Vietnam]. Vol. 2. Muséum National d'Histoire Naturelle, Laboratoire de Phanérogamie, Paris, France. pp. 3–7.

P. Polprasid

Musa L.

Sp. pl.: 1043 (1753), Gen. Pl. ed. 5: 466 (1754).

MUSACEAE

x = 10, 11; $2n$ = 22 (most species); $2n$ = 20 (*M. salaccensis*); most edible fruit cultivars are triploid.

Major species and synonyms

- *Musa acuminata* Colla (AA genome, seeded), Mem. Accad. Sci. Torino 25: 394 (1820), synonyms: *M. zebrina* Van Houtte ex Planchon (1854/55), *M. malaccensis* Ridley (1893).
- *Musa balbisiana* Colla (BB genome, seeded), Mem. Accad. Sci. Torino 25: 384 (1820), synonym: *M. brachycarpa* Backer (1924).
- *Musa halabanensis* Meijer, Acta Bot. Neerl. 10: 250 (1961).
- *Musa salaccensis* Zoll., Syst. Verz. Ind. Archip. 1: 74 (1854).
- *Musa* L. (edible fruit cultivars).

Vernacular names Banana (En). Bananier (Fr). Indonesia/Malaysia: pisang. Papua New Guinea: banana (Pidgin). Philippines: saging. Burma: nget pyo thee. Cambodia: cheek nam' vaa. Laos: kwàyz. Thailand: kluai. Vietnam: chu[oos]i.

Origin and geographic distribution The genus *Musa* L. has its origin in South and South-East Asia. *M. acuminata* is native to South-East Asia. *M. balbisiana* is native to the eastern part of India, but is now widely distributed in South-East Asia. These two wild diploid bananas with seeded inedible fruits are the major parents of most edible bananas. The other two wild species have very restricted distribution. *M. halabanensis* is confined to West Sumatra, and *M. salaccensis* to Sumatra and Java. The cultivated fruit bananas are pantropical.

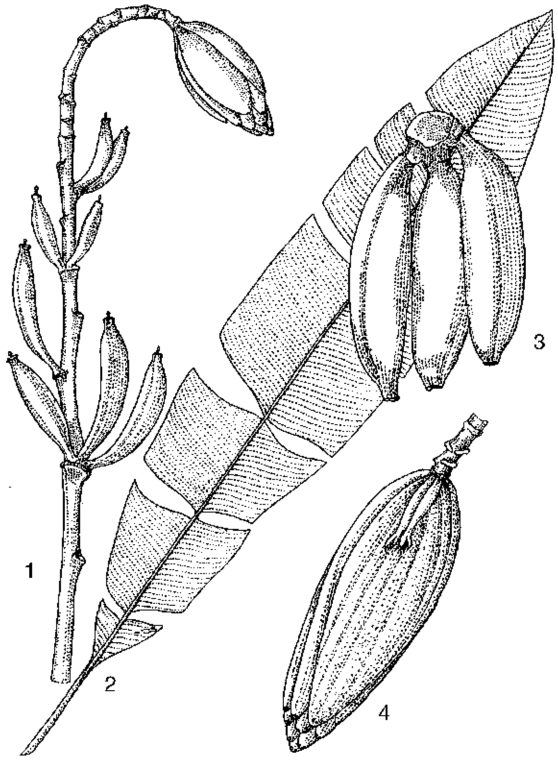
Uses The banana inflorescence is a much appreciated vegetable. It is the part still enclosed within protective bracts: sometimes the entire young inflorescence, but usually the 'male bud' at the top of the infructescence which continues to produce male flowers but no fruits. The inner part is eaten raw with fried noodles, after boiling in water, or after roasting in hot ashes. It is common in Thai style hot sour soup. A change of boiling water is sometimes needed to lessen the astringent taste. The lower, soft inner part of the pseudostem is also eaten fresh or boiled with a capsicum sauce or in curries.

Ripe fruits of *M. balbisiana* are also sometimes used for vegetable dishes, after removal of the seeds.

Production and international trade The inflorescence buds of the seeded bananas are collected from wild plants occurring in the forest, with the exception of *M. balbisiana* which is also occasionally raised in home gardens. The buds of a number of cultivars of the seedless edible bananas such as 'Pisang Awak' (*Musa* ABB), 'Bluggoe' (*Musa* ABB) and 'Saba' (*Musa* BBB) are used for the same purpose. Banana inflorescences constitute a common market vegetable, but no production statistics are available.

Properties The nutritional value of the inflorescence buds varies considerable with species, age and origin. 100 g fresh edible portion has been reported to contain: water 90.2 g, protein 1.2 g, fat 0.3 g, carbohydrates 7.1 g, Ca 30 mg, P 50 mg, Fe 0.1 mg. The energy value is about 150 kJ/100 g.

Botany Tree-like perennial herbs, 2–9 m tall, with a short underground stem (corm) from which short rhizomes grow to produce a clump of aerial shoots (suckers). Roots adventitious. Pseudostem consisting of overlapping leaf-sheaths which are tightly rolled round each other to form a rigid bundle. Leaf-blades oblong, 100–500 cm × 25–100 cm, with a strong midrib and well-marked pinnately arranged, parallel veins. One terminal inflorescence rises from each corm, extending through the centre of the pseudostem; it is a compound spike of flowers which are arranged in several groups, compact and conical when young; each group is enclosed in a large ovate, pointed, reddish bract; female flowers develop proximally, male flowers at the distal end of the inflorescence, in the middle neuter flowers are sometimes present; finally the mature infructescence bears hands of fruits, usually followed by a long bare axis formed by abscission of the male flowers and subtending bracts, and terminating in a growing point ('male bud') which continues to produce bracts and male flowers. Fruit a berry, subcylindrical, often curved, rounded or nearly 4-sided in cross-section, full of seeds in wild species, seedless in fruit cultivars.



Musa salaccensis Zoll. – 1, infructescence; 2, leaf; 3, hand of fruits; 4, growing point of inflorescence ('male bud').

- *M. acuminata:* inflorescence horizontal or pendulous, peduncle usually downy or hairy, male flowers not red, fruits subsessile, seeds compressed; extremely variable and at least 5 subspecies are distinguished.
- *M. balbisiana:* inflorescence horizontal or pendulous, peduncle glabrous, male flowers tinged with red, fruits long-pedicellate, seeds subglobose.
- *M. halabanensis:* large herb, up to 9 m tall, gigantic in all its parts with the exception of the very small globular seeds, 3–4 mm × 2–3 mm; it produces an abundant, sticky juice; male bud ovoid, 15–20 cm × 9–12 cm, dark violet.
- *M. salaccensis:* small herb, not more than 3 m tall, with erect inflorescence, the fruits arranged in one row instead of 2, with turbinate seeds; male bud ovoid, ca. 15 cm × 5–6 cm, light red-violet, tasting bitter.

Ecology Bananas are plants of the tropical humid lowlands. However, they frequently occur up to altitudes of 1200 m, *M. acuminata* and *M. halabanensis* even up to 1800 m. In the wild they occur mainly in forests, on forest edges, in ravines and on water sides. Bananas are moisture-loving, and a monthly rainfall of 200 mm is considered optimal. The optimum temperature for growth is about 27°C. Temperatures should not drop much below 15°C and not exceed 35°C. The best soils are deep friable loams with good drainage and aeration. Bananas are very sensitive to strong winds.

Agronomy Bananas are generally propagated by suckers, but the wild bananas can also be propagated by seeds. These usually germinate in 3–4 weeks time. Pieces of corm can also be used as planting material. In the case of deliberate cultivation (mainly *M. balbisiana*) in home gardens, organic fertilizers are usually applied and earthing-up is frequently practised to improve the anchorage of the plants.

Normally, however, the inflorescences of seeded bananas are gathered from natural stands. If the fruits are not used at all (e.g. *M. salaccensis*) the inflorescence can be cut at any stage of development. If the fruits serve a purpose (e.g. ripe fruits of *M. balbisiana*) the 'male buds' are cut as soon as the last two hands of the bunch have appeared. The outer bracts are usually removed, as they are more fibrous than the inner parts.

Genetic resources and breeding South-East Asia is the centre of diversity of *Musa*. A regional collection of germplasm is being maintained at the Bureau of Plant Industry, Davao City, the Philippines. In addition, national collections are maintained in Malaysia (MARDI), Thailand (Kasetsart University), Indonesia (SOHRI) and the Philippines (UPLB). Most research is concentrated on selection and characterization of edible cultivars, and relatively little attention has been paid to the wild species.

Prospects Banana inflorescences or 'male buds' as a product of gathering from the wild will gradually disappear together with the natural stands of wild bananas. Cultivation for the sole purpose of the inflorescence is a waste of energy in view of the extremely low harvest index. Banana 'male buds' only have a future as a by-product of banana fruit production, but the marketable volume is probably too small to take aspects of vegetable quality into consideration in selection work.

Literature |1| Espino, R.R.C., Jamaluddin, S.H., Bechamas Silayoi & Nasution, R.E., 1991. Musa L. (edible cultivars). In: Verhey, E.W.M. & Coronel, R.E. (Editors): Plant resources of South-East Asia 2. Edible fruits and nuts. Pudoc/Prosea, Wageningen, the Netherlands. pp. 225–233. |2| Meijer, W., 1961. Notes on wild species of Musa from Sumatra. Acta Botanica Neerlandica 10: 248–256. |3| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 511–522. |4| Simmonds, N.W., 1962. The evolution of bananas. Tropical Science Series. Longmans, London, United Kingdom. 170 pp. |5| Stover, R.H. & Simmonds, N.W., 1987. Bananas. 3rd Edition. Tropical Agriculture Series. Longman, London, United Kingdom. 468 pp.

R.E. Nasution

Neptunia oleracea Loureiro

Flora Cochinchinensis: 654 (1790).

LEGUMINOSAE

2n = 56

Synonyms *Neptunia prostrata* (Lamk) Baillon (1883), *N. natans* (L.f.) Druce (1917).

Vernacular names Water mimosa (En). Neptunie potagère (Fr). Indonesia: kemon (Lampung). Malaysia: keman air, keman gajah, tangki. Cambodia: kânhchhnaèt. Laos: ('phak) kas'ééd. Thailand: phakkrachet (central), phakchit (peninsular). Vietnam: rau nh[us]t (South), rau r[us]t (North).

Origin and geographic distribution Water mimosa is widely distributed in the tropics of both hemispheres. The origin of the species is uncertain. It occurs wild and cultivated as a vegetable throughout South-East Asia, particularly in Thailand and Indo-China.

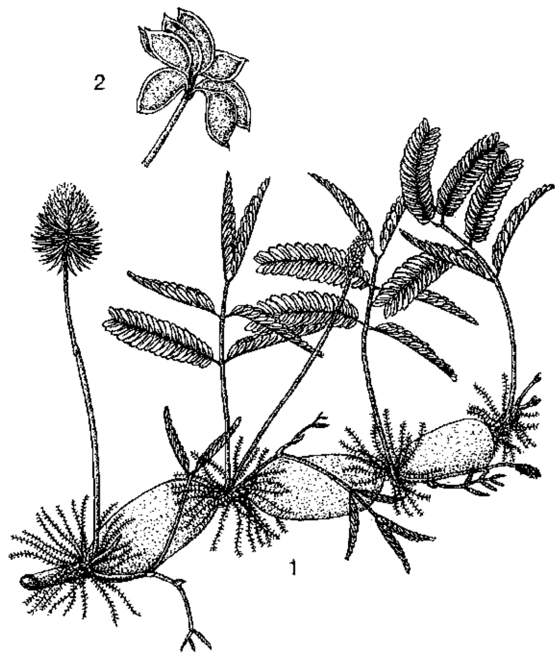
Uses Water mimosa is mainly gathered and cultivated for its young shoots, which are consumed as a vegetable, raw, cooked, or fried. It is a common ingredient of Thai cuisine. The people of Kelantan (Malaysia) use the root as an external remedy for necrosis of the bones of the nose and hard palate. The juice of the stem is squeezed into the ear to cure earache and the root is used in the advanced stage of syphilis in Malaysia.

Production and international trade Water mimosa is only locally grown and is marketed on a small scale. No data on production and trade are available.

Properties Per 100 g edible portion the shoots contain: moisture 89.4 g, protein 6.4 g, fat 0.4 g, carbohydrates 0.8 g, fibre 1.8 g, ash 1.2 g, Ca 387 mg, P 7 mg, Fe 5.3 mg, vitamin A 5155 IU, vitamin B_1 0.12 mg, vitamin B_2 0.14 mg, niacin 3.2 mg and vitamin C 1.8 mg. The energy value is 134 kJ/100 g.

Botany Perennial herb, sometimes grown as an annual, aquatic, floating or prostrate near water's edge. Taproot thick, becoming woody. Stems terete up to 1.5 m long, rarely branched, becoming detached from the primary root system, forming spongy-fibrous swollen internodes (to float) and producing fibrous adventitious roots at the nodes when growing in water. Leaves alternate, bipinnate, with 2–3(–4) pairs of pinnae; petiole angled, 2–7 cm long; rachis 3.5–8 cm long, angled; rachis of pinnae winged, 2.5–6.5 cm long; leaflets 8–20 pairs per pinna, oblong, 5–18 mm × 1.5–3.5 mm, asymmetrical, glabrous or with sparsely ciliate margins. Inflorescence an axillary, erect or slightly nodding solitary spike which is obovoid in bud, 30–50-flowered; peduncle 5–30 cm long; flowers small, sessile, yellow, lower ones sterile, upper ones bisexual. Bisexual flowers with campanulate calyx of 2–3 mm and 5-lobed; corolla with 5 regular petals, free, 3–4.5 mm long; stamens 10, free, 6–9 mm long; pistil up to 9 mm long, usually exserted beyond the stamens. Fruit a legume, broadly oblongoid and flat, 2–3 cm × 1 cm, dehiscent along both sutures; fruit stalk longer than the persistent calyx. Seeds 4–8, compressed ovoid, 4–5 mm × 2.5–3.5 mm, brown.

In Thailand, water mimosa is usually grown at



Neptunia oleracea Loureiro – 1, habit; 2, infructescence.

the beginning of the rainy season (May). Under favourable conditions young shoots may elongate at a rate of 5–7 cm per day. The plants start to flower during the dry season (December). Its cropping period is 4–6 months.

Ecology Water mimosa is a common floating plant in and around fresh water ponds, swamps and canals at low altitudes up to 300 m. When the water level falls, the plants perish. The rooted land form has smaller leaves and flowers, and has no spongy floating tissue. The plant prefers 30–80 cm depth of slow-moving water, full sun and hot and humid conditions. Shade, brackish water and saline soil adversely affect plant growth.

Agronomy Water mimosa can be propagated by seed, but the conventional method is by stem cuttings. Two cultivation methods are practised in Thailand: in inundated fields normally used for rice, and in canals. In the case of rice fields the land is levelled and ploughed in the same way as for transplanted rice. The plot is filled with water to a depth of 20–30 cm, and 3–5 stem cuttings, 50–150 cm long are directly planted at a spacing of 1 m × 2 m. One week after planting, the water level is raised and kept at 50 cm. When growing in canals where the depth exceeds 50 cm, stakes are needed to hold the floating cuttings in place.

Aquatic weeds, such as *Pistia stratiotes* L., *Eichhornia crassipes* (Martius) Solms, *Lemna* spp., and *Ludwigia adscendens* (L.) Hara, must be regularly cleared from the water. When grown in rice fields, application of 150–300 kg/ha of a mixed N and P fertilizer is recommended. This amount is given in split doses, the first at planting, subsequent ones after each harvest during the rainy season. The water level should be lowered to 20–30 cm depth before each fertilizer application, and raised up to 50 cm depth two days later. No fertilizer is applied when water mimosa is grown in canals.

The first harvest can be done 3–4 weeks after planting and subsequently at intervals of 5–7 days during the 4–6 months cropping season. Young shoots of 50–100 cm length are cut with a sharp knife and washed. They may be disinfected by dipping in a dilute alum solution for a few minutes. The spongy tissue may be removed by keeping the plants under water for about one week, but this treatment is not commonly practised. Bundles of 250 shoots are wrapped in plastic film and sent to the markets for sale in smaller bundles. A yield of 30 000–50 000 shoots/ha for each harvest has been reported.

No disease has yet been recorded, and very few pests attack water mimosa. The larvae of the leaf roller *Synclita* sp. may attack the spongy tissue and stem. Synthetic pyrethroid insecticides are recommended for the control of this insect. Plant-eating fishes, turtles, ducks and geese are found to feed on water mimosa.

Genetic resources and breeding Only local selections are grown. No work has been undertaken on germplasm collection and breeding.

Prospects Water mimosa is a nutritious and productive vegetable. Research should focus on the selection of productive and marketable types, and improvement of cultivation methods.

Literature |1| Division of Food Science, 1981. Nutritional value of Thai foods. Ministry of Public Health, Bangkok, Thailand. 16 pp. |2| Nielsen, I.C., 1985. Leguminosae – Mimosoideae. In: Smitinand, T. & Larsen, K. (Editors): Flora of Thailand. Vol. 4(2). The Forest Herbarium, Royal Forest Department, Bangkok, Thailand. pp. 146–149. |3| Saengtham, C., 1987. Khlong phakkrachet haeng lumnam nakhonchaisri [Water mimosa]. Thankasettakam [Agricultural Base Journal] 5(50): 25–30. |4| Tanphiphat, S., 1985. Phak-krachet watchaphuet thimi khunnakha [Water mimosa]. Warasarn kaset phrachomklao [King Mongkut's Agricultural Journal] 3(2): 29–39. |5| Windler, D.R., 1966. A revision of the genus Neptunia (Leguminosae). Australian Journal of Botany 14: 379–420.

Y. Paisooksantivatana

Ocimum americanum L.

Cent. pl. 1: 15 (1755).

LABIATAE

$2n = 24$, possible occurrence of a polyploid series

Synonyms *Ocimum africanum* Lour. (1790), *O. canum* Sims (1823), *O. brachiatum* Blume (1826).

Vernacular names Hoary basil, American basil (En). Indonesia: kemangi, serawung, selasih putih. Malaysia: selaseh, kemangi, ruku-ruku. Thailand: maenglak. Vietnam: rau h[us]ng.

Origin and geographic distribution *O. americanum* occurs wild and cultivated throughout tropical Africa and tropical Asia. Its exact origin is unknown. In South-East Asia it has been reported from the continental parts, from Indonesia and Papua New Guinea. Its occurrence in the Philippines is doubtful. It has also been introduced into tropical America and some islands of the West Indies.

Uses Whereas sweet basil (*O. basilicum* L.), shrubby basil (*O. gratissimum* L.) and holy basil (*O. tenuiflorum* L.) are very fragrant and used as condiments, medicinal plants, or for ceremonial uses, *O. americanum*, being mild in flavour, is extensively cultivated in Indonesia, Malaysia and Thailand for the young leaves, which are eaten raw as a vegetable side-dish. The fragrant leaves are also added to various dishes with a fishy or disagreeable smell.

The nutlets swell in water into a gelatinous mass often used in sweet cooling drinks as can be done likewise with nutlets of *O. basilicum*.

In traditional medicine, hoary basil is used for several ailments. Decoctions are used for coughs, pounded leaves are placed on the forehead to relieve catarrh or on the chest for respiratory problems, the whole plant is used in baths to treat rheumatism, renal colic and calcifications. More recently, the plant has been listed as a potential medicine against cancer.

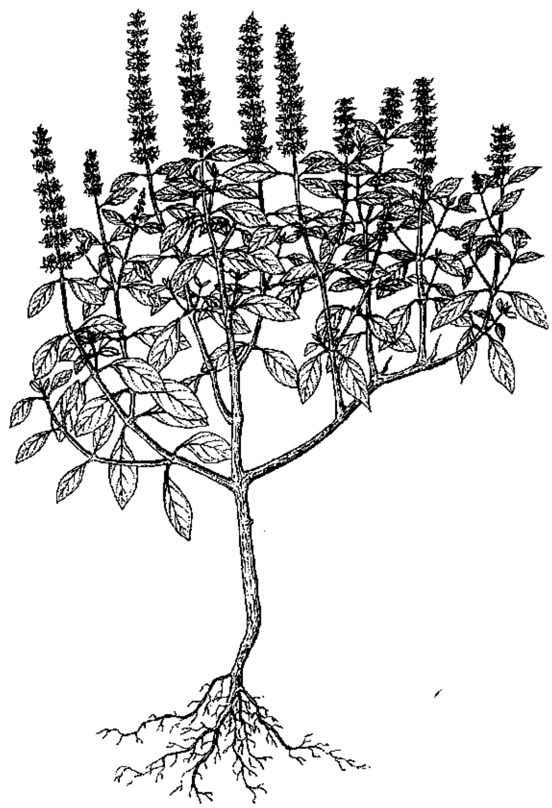
The essential oil of *O. americanum* is used in soap and cosmetics. It has been reported to exhibit fungitoxic properties (without phytotoxic side-effects). Hoary basil has been planted on a large scale in the Commonwealth of Independent States, Kenya and Pakistan for the production of camphor, which has medicinal and industrial applications (celluloid, fireworks).

Production and international trade There are no statistics on the production of hoary basil for vegetable use, but it is locally important. It is an indispensable ingredient of Sundanese cuisine (West Java), often cultivated in home gardens and generally offered for sale on local markets.

Properties Per 100 g edible portion, hoary basil contains: water 87 g, protein 3.3 g, fibre 2.0 g, Ca 320 mg, Fe 4.5 mg, and vitamin C 27 mg. The energy value is 180 kJ/100 g.

O. americanum contains citral, camphor, and methyl-cinnamate in varying proportions, leading to spicy odours like cinnamon, clove and lemon.

Description An erect, much-branched, annual, aromatic herb, 0.3–1 m tall. Stem and branches quadrangular, yellowish-green, densely white-pilose in young parts, less so when older. Leaves simple, decussate, petiolate; petiole up to 2.5 cm long; leaf-blade lanceolate to elliptical, 2.5–5 cm × 1–2.5 cm, cuneate at base, margin entire, apex acute, glabrous, gland-dotted on both surfaces. Inflorescence up to 15 cm long, composed of decussate, 3-flowered cymes, appearing as 6-flowered whorls (verticillasters) up to 3 cm apart, terminal, simple or branched; peduncle and axis quadrangular; bracts elliptical-lanceolate, 2–3 mm long, hairy, persistent; pedicel up to 4 mm long, strongly recurved at top; calyx bilobed, in flower 2–2.5 mm long, in fruit 3–4.5 mm, villous inside, pubescent with long white hairs outside, upper lobe flat, suborbicular, lower lobe canaliculate, sharply 4-toothed at top; corolla tubular, 2-lipped, 4–6 mm long, white, upper lip strongly recurved at top and crenately 4-lobed, lower lip entire, smaller than upper lip; stamens 4, didynamous, slender and exserted; pistil with 4-ovuled and 4-lobed ovary, filiform style and 2-lobed stigma. Fruit composed of 4 distinct nutlets, enclosed within the tube of the persistent calyx; nutlets ovoid, up to 1.25 mm × 1 mm, black; in water the nutlet-wall produces a thick white cover of slimy threads within several minutes. Seed free within the nutlet.



Ocimum americanum L. – flowering and fruiting plant.

Growth and development Seeds normally germinate within 1–2 weeks after sowing. Germination is epigeal. Flowering starts 8–12 weeks after sowing, when plants are about 25 cm tall and continues until the plants die, but data differ considerably with cultivar. Insect pollination is normal, causing cross- and self-pollination. Seed maturation takes 14–20 weeks from sowing. In the wild, flowering and fruiting occurs year-round.

Other botanical information Within the genus *Ocimum* L., species delimitation is far from being clear. Here the view expressed in Flora Malesiana is being followed, where 4 species for Malesia are distinguished (*O. americanum*, *O. basilicum*, *O. gratissimum* and *O. tenuiflorum*), but differences are small and many hybrids seem to exist. *O. americanum* could well be a diploid form ($2n = 24$) of the tetraploid ($2n = 48$) *O. basilicum*. For the cultivated Ocimums, recognition of one taxon *O. basilicum*, subdivided into cultivar groups and cultivars might give a solution, but first a thorough revision of the genus is needed.

Ecology Hoary basil is often found growing on roadsides, in fields, in teak forests, and in open waste places close to settlements. It prefers sunny, wind-sheltered spots. It grows well from the plains up to 500(–2000) m altitude, preferably on upland soils, but it is also planted on dikelets of paddy fields.

Agronomy Hoary basil is extensively cultivated in home gardens in Indonesia and Malaysia, but also in commercial market gardens near the large urban centres. It is propagated by seed, usually sown in a seed-bed, and transplanted 3–4 weeks later on beds at planting distances of 20–30 cm either way. Weed control is important, especially because weeds can ruin the quality if they are included in the harvested crop.
No serious diseases and pests have been reported. Harvesting starts about 2–3 months after planting, and is done subsequently at regular intervals. Harvesting usually consists of cutting young shoots about 10 cm long, but cutting back the whole plant is also practised, as well as once-over harvest by uprooting. Plants selected for seed production are not pruned. Seeds are harvested by cutting dry inflorescences, which are sun-dried and threshed by beating.

Genetic resources and breeding Germplasm collection of *Ocimum* spp. by the Centre for Research and Development in Biology, Bogor, Indonesia, showed that *O. americanum* and *O. tenuiflorum* are the most common species in Indonesia. The *O. americanum* samples showed considerable variation in stem and flower colour, leaf structure, leaf scent and taste.
Selection and breeding work has not been undertaken in the South-East Asian region. Interspecific hybrids with *O. basilicum* are easily obtained, but they show strongly reduced pollen fertility.

Prospects Although there is considerable information on *Ocimum* spp., it can often hardly be used because of a lack of clarity about the taxonomical identity of the material studied. The priority in *Ocimum* research is to unambiguously establish a link between taxonomical and non-taxonomical information.

Literature |1| Boonklinkajorn, P. & Chomchalow, N., 1968. Preliminary study of the effect of plant density on the yield of Ocimum spp. Thailand Institute of Scientific and Technological Research (TISTR), Bangkok, Thailand. Research Project No 11/18. Technical Report No 3. 18 pp. |2| Darrah, H.H., 1974. Investigation of the cultivars of the basils (Ocimum). Economic Botany 28(1): 63–67. |3| Keng, H., 1978. Labiatae. Ocimum. In: van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 8. Sijthoff & Noordhoff International Publishers, Alphen aan den Rijn, the Netherlands. pp. 376–379. |4| Lubis, S.H.A., Murni Dwiati & Prana, T.K., 1986. Collection of Ocimum spp. in Indonesia. IBPGR/RECSEA Newsletter 10(2): 8–10.

A.T. Sunarto

Oenanthe javanica (Blume) DC.

Prodr. 4: 138 (1830).
UMBELLIFERAE
$2n = 22$

Synonyms *Sium javanicum* Blume (1826), *Oenanthe stolonifera* DC. (1830).

Vernacular names Water dropwort, Indian pennywort, water celery (En). Persil séri (Fr). Indonesia: tespong (Sundanese), pampung (Javanese), bacarongi (Sumatra). Malaysia: selom, pipopo. Papua New Guinea: nase. Philippines: ongsoy (Tagalog), alusis (Bontoc), holog (Ifugao). Laos: s'ii s'aangz (in common with *Apium graveolens*). Thailand: phakchi-lom (general), phakan (northern). Vietnam: rau c[aaf]n, rau c[aafl]n n[uw][ows]c.

Origin and geographic distribution *O. javanica* is of Asiatic origin and since ancient times has been widespread in South, South-East and East Asia, from Pakistan to Japan and Taiwan, and from northern China down to the tropical parts of Australia (Queensland).
In most South-East Asian countries it is a minor vegetable, gathered from the wild or cultivated on a small scale, but it is one of the most common greens in the highlands of Papua New Guinea.

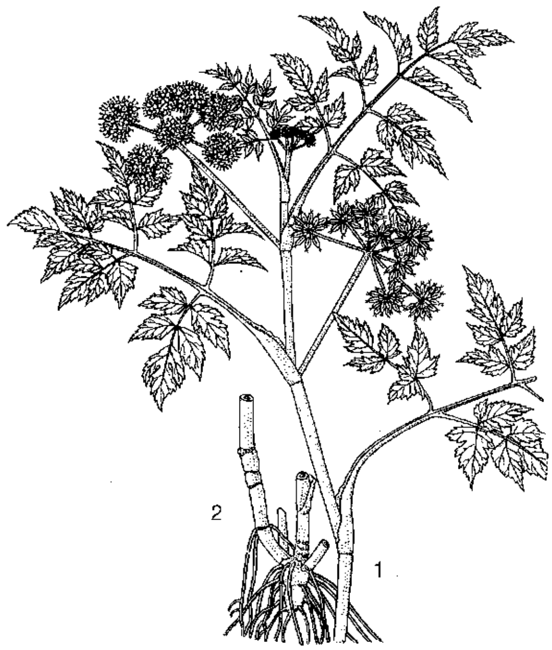
Uses Water dropwort has a long history of being

used as a leafy vegetable or condiment in East and South-East Asia. In China, it was used as food as early as 700 BC. Its cultivation in Japan dates at least back to 750 AD. The plant smells strongly of carrot leaves when bruised, and its leaves and young stems are used raw as well as cooked briefly. It is a delicious substitute for celery. In Japan, where it is known as 'seri', finely chopped leaves are used in 'one pot' dishes such as 'sukiyaki'. In Papua New Guinea it is eaten raw or steamed, usually with meat or fish.
Water dropwort can also be used as feed for fish and small ruminants. The seed and other plant parts are used medicinally.

Production and international trade Water dropwort is a common market vegetable in the region, but there are no statistics on production or traded volume.

Properties Per 100 g edible portion, *O. javanica* contains: water 91.6 g, protein 1.1 g, fat 0.4 g, carbohydrates 4.4 g, fibre 1.0 g, ash 1.5 g, Ca 138 mg, P 43 mg, Fe 2.3 mg, vitamin A 0.51 mg, vitamin B_2 0.31 mg, vitamin C 60.5 mg. The energy value is 110 kJ/100 g.
O. javanica is not known to contain the very poisonous oenanthotoxin present in some other *Oenanthe* species like the water hemlock (*O. crocata* L.), but it contains the hallucinatory drug myristicine. The seeds yield about 3.5% of an essential oil which is a good source of limonene. The essential oil of the leaves contains 117 identified compounds. The essential oil of the flowering tops has fungicidal and bactericidal properties.

Botany A perennial, glabrous, often aquatic herb. Stems terete, erect or ascending from a creeping base, hollow, 10–100 cm long, much branched, sometimes tinged with red. Leaves alternate; petiole up to 12 cm, often sheathing over most of its length, with membranous margins; leaf-blade oblong to ovate in outline, 5–30 cm × 5–15 cm, pinnate to tripinnate; ultimate segments ovate to narrowly oblong, 0.5–7 cm × 0.3–3.5 cm, with serrate or entire margins, above dark green and dull, beneath lighter coloured with transparent nerves. Inflorescence a compound, many-flowered umbel, terminal and opposite the leaves; peduncle longitudinally furrowed, up to 25 cm long; primary rays 5–15, 0.5–3 cm long; involucres none or 1; bracteoles at the base of the umbellules (involucels) 2–8, linear, green; secondary rays (pedicels) 10–25, 2–5 mm long; flowers small, white; calyx teeth 5, distinct, acute, dark green, nearly 0.5 mm; petals 5, obovate, up to 2 mm × 1 mm, glabrous; stamens 5, patent, filaments white, anthers small, yellowish brown; ovary glabrous; style long, persistent. Fruit a schizocarp, glabrous; mericarps 2–3 mm × 0.5–1 mm, with swollen ribs, the marginal ones much more prominent than the dorsal ones.



Oenanthe javanica (Blume) DC. – 1, flowering and fruiting shoot; 2, base of plant.

O. javanica is very variable as to the dimensions of all its parts and the compoundness of the leaves. Forms formerly described as distinct species, are all connected by intermediates. There are also red-leaved forms, but collection from the wild should be avoided because these red forms are most easily confused with related poisonous species.

Ecology Water dropwort occurs wild in swampy localities, along streams and in wet grasslands and clearings. It is a cool-season plant, but has wide altitudinal adaptation, occurring from sea-level to elevations of 2800 m. It thrives in warm wet areas, although some forms have frost-hardy roots and stolons.

Agronomy Water dropwort is strongly tillering and can be easily propagated by division, but also by stem cuttings, which establish quickly in moist soil. It can also be raised from seed (e.g. in Japan), but germination is reported to be sometimes erratic. The planting distance depends on the harvesting method. For a 'once-over' harvest of young plants (before flowering), plants can be spaced closely at 10–15 cm × 10–15 cm. If harvested repeatedly, it is planted at distances of 40–100 cm × 40–100 cm, and cut for the first time about 2 months after planting and subsequently at intervals of about one month for a period of 1–3 years. No diseases and pests are known. In Papua New Guinea, a yield of 1 kg/m^2 per harvest has been recorded.

Genetic resources and breeding Germplasm collections of minor, traditional vegetables are very rare, and therefore the small collection of *O. javanica* maintained at the Highlands Agricultural Experiment Station, Aiyura, Papua New Guinea, is worth mentioning.
Little breeding and selection work has been done.

Prospects *O. javanica* is one of the most popular traditional vegetables in South-East Asia. It is a good alternative for celery, with the additional advantages that it is easier to grow and can be maintained around the year without replanting.

Literature |1| Buwalda, P., 1949. Umbelliferae. Oenanthe. In: van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Ser. 1. Vol. 4. Noordhoff-Kolff, Djakarta, Indonesia. pp. 135–136. |2| Kuebel, K.R. & Tucker, A.O., 1988. Vietnamese culinary herbs in the United States. Economic Botany 42(3): 413–419. |3| Larkcom, J., 1991. Oriental vegetables. The complete guide for garden and kitchen. John Murray, London, United Kingdom. p. 131. |4| Mansor, P., 1988. Ulam-ulam tradisional Malaysia [Traditional vegetables in Malaysia]. Teknologi sayur-sayuran [Vegetable Technology] 4: 1–5. |5| Tumana, C.W., 1986. Genetic resources of crop plants at the Highlands Agricultural Experiment Station, Aiyura, Papua New Guinea. IBPGR/RECSEA Newsletter 10(4): 4–6.

D. Sasmitamihardja

Parkia speciosa Hassk.

Flora 25(2). Beibl.: 55 (1842).
LEGUMINOSAE
$2n = 24, 26$

Synonyms *Parkia macrocarpa* Miquel (1860).

Vernacular names Indonesia: petai, pete (Javanese), peuteuy (Sundanese). Malaysia: petai. Thailand: sator (general), sator dan (peninsular), sator kow (peninsular).

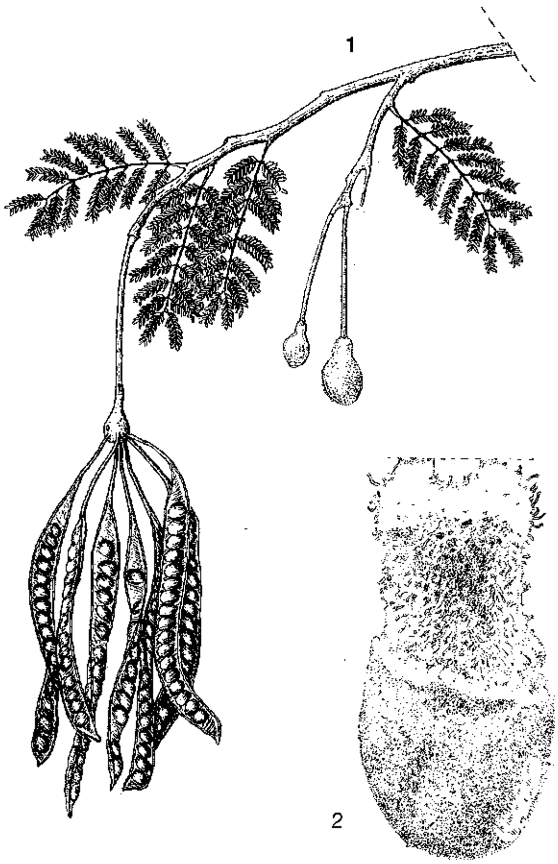
Origin and geographic distribution *P. speciosa* is native to Malaysia, Brunei, Indonesia, and peninsular Thailand. Occasionally it is cultivated, but rarely outside its native area.

Uses The seeds of *P. speciosa* are one of the most relished native vegetables in spite of their strong smell (stinkbean in Dutch) if not properly heated. Fresh seeds, young or ripe, are eaten raw, cooked or roasted as a side-dish with rice. Seeds preserved by sun drying should be peeled before they are used. They are fried in oil or steeped in water for 24 hours and cooked. Young leaves and the pear-shaped receptacle of the inflorescence can also be consumed raw as lalab, but they are not used to a great extent.
The seeds are also considered beneficial in treating liver disease (hepatalgia), oedema, inflammation of the kidneys (nephritis), diabetes, and as anthelmintic; the leaves are used against jaundice. The timber is fairly heavy but not very hard and durable; it can be used for boxes and cabinet work. *P. speciosa* has been found useful as a shade tree for coffee and nurseries although its growth is rather slow.

Production and international trade Petai is only locally an important product of commerce, and always fetches a good price. It seems to be in short supply often, and prices increase sharply in times of scarcity.

Properties The chemical composition of the edible portion depends largely on the ripeness and the freshness of the seeds. Data reported per 100 g are: water 71 g, protein 8 g, fat 8 g, carbohydrates 11 g, Ca 76 mg, P 83 mg, Fe 1 mg, vitamin A 734 IU, vitamin B_1 0.1 mg, vitamin B_2 0.01 mg, niacin 1 mg, vitamin C 6 mg. The energy value is 630 kJ/100 g.
The seeds contain also antinutritional factors such as tannins (6% on a dry weight basis). The medicinal properties are probably related to certain alkaloids (1.6% on a dry weight basis). The offensive smell is due to some sulphur compounds.

Description Tree up to 30 m tall with smooth reddish-brown bark and puberulous branchlets. Leaves alternate, bipinnate; petiole 2–6 cm long, with subcircular gland about 1 cm above the base; rachis 18–30 cm long, with subcircular glands between the junctions of the basal pairs of pinnae; pinnae 14–18 pairs, 3–9 cm long, with circular glands below the basal pairs of leaflets; leaflets (18–)31–38 pairs per pinna, linear, 5–9 mm × 1.5–2.2 mm, base at one side expanded into an apiculate auricle, apex rounded, mucronate. Inflorescence a pear-shaped pendulous head, 2–5 cm in diameter; peduncle 20–45 cm long; flowers small and numerous, brown-yellow, male or asexual at the base of the head, bisexual at the apex of the head; calyx and corolla tubular, 5-lobed; stamens



Parkia speciosa Hassk. – 1, flowering and fruiting shoot; 2, inflorescence.

(staminodes) 10, filaments at base united into a tube; ovary stipitate. Fruit a legume on a long stalk, 35–45 cm × 3–5 cm, usually strongly twisted and prominently swollen over the 12–18 seeds. Seed broadly ovoid, 2–2.5 cm × 1.5–2 cm, horizontal in the pod, testa very thin, white.

Growth and development *P. speciosa* starts bearing at the age of about 5 years. The flowers are pollinated by bats. It takes 60–70 days from flowering to harvesting the ripe pods. Production is year-round but with one or two peak periods.

Other botanical information In Java two kinds of *P. speciosa* are recognized. The form with large seeds is called 'petai gede' or 'segobang', the form with small seeds is 'petai pare'. A wild form has been described with very long pods and a high protein content (20%) of the seeds, occurring in West Sumatra. In Thailand, many forms of *P. speciosa* ('sator') have been named, among them three in southern Thai-land: 1) 'sator kow', the most popular one; seeds are small and have a strong odour with rather sweet taste, 2) 'sator dan'; seeds are larger, harder, and have an even stronger odour and taste than 'sator kow', 3) 'sator tae', hardly suitable for consumption because of hard seeds.

Although *P. speciosa* is by far the most important *Parkia* vegetable, 6 other *Parkia* species in South-East Asia are used in a similar way or as a substitute:

- *P. timoriana* (DC.) Merrill. Synonym: *P. roxburghii* G. Don. In the literature often named *P. javanica* (Lamk) Merrill, but this is a dubious, incorrect name. Vernacular names: Indonesia and Malaysia: kedahung; Philippines: kupang; Thailand: riang. This species is most widespread in tropical Asia, from India to New Guinea. It is a large forest tree with ecological preferences similar to *P. speciosa*, but also able to grow under more seasonal climatic conditions in mixed deciduous and dry evergreen forests. It is also cultivated occasionally. Its fruits are straight, the seeds smaller and harder than those of *P. speciosa*. The use of the seeds against colic is perhaps more important than its culinary value.
- *P. sumatrana* Miquel. Synonyms: *P. insignis* Kurz, *P. streptocarpa* Hance, *P. dongnaiensis* Pierre. Vernacular names: Burma: myouk-tanyet; Cambodia: royôông; Laos: 'hua 'lôn; Thailand: lukding; Vietnam: th[us]i. This species is native in Sumatra, Borneo, Peninsular Malaysia, Burma, Thailand and Indo-China. It is a tree scattered near streams in dry evergreen forests in hilly habitats. Its large, truncate-rounded leaflets (up to 3 cm × 1 cm) are characteristic.
- *P. intermedia* Hassk. ex Hoeven & de Vries. This is a species occurring on Java only. Its characteristics are intermediate between *P. speciosa* and *P. timoriana* and most probably it is a hybrid between those two species. Two forms are distinguished: 'petir', a really intermediate form, and the better liked 'gunjae', which is closer to *P. speciosa*. The trees are rarely cultivated and occur occasionally in the forests of the lower mountainous regions of West Java.
- *P. harbesonii* Elmer. An indigenous tree of the Philippines, growing in the forests of Palawan. Vernacular name: butad (Tagbanua).
- *P. sherfeseei* Merrill. An indigenous tree of the Philippines, growing near tidal streams in Mindanao. Vernacular name: kunding (Cebu Bisaya).
- *P. leiophylla* Kurz. A rare tree of Burma and

Thailand, growing near streams in mountainous forests. Vernacular name: Thailand: sato.
In Africa, the fruits and seeds of *P. biglobosa* (Jacq.) Benth. and *P. filicoidea* Welw. ex Oliver constitute a popular food.

Ecology *P. speciosa* is frequently cultivated from the plains up to elevations of 1500 m, but it does best between 500–1000 m. At low elevations there are pest problems, and above 1000 m productivity decreases. Wild trees are found in primary and secondary forest, mostly at low elevations.

Propagation and planting Propagation is usually by seed. Farmers often collect young seedlings from wild trees, or freshly harvested seeds are sown in a seed-bed or in individual baskets or polybags. One year after sowing, when the plants are 0.5–1 m tall, they are transplanted to the field at distances of at least 10 m × 10 m. *P. speciosa* can also be propagated by stem cuttings and buddings. Budding on the stock of *P. timoriana* seems promising to enhance growth and development.

Husbandry Petai cultivated in home gardens is preferred above petai collected from the wild, because due to fertilizing and perhaps selection the seeds are larger and more savoury. It is recommended to apply complete fertilizer NPK 16–20–0 twice a year for young trees, and NPK 12–24–12 twice a year for mature trees. Competitive weeds should be eradicated at least once a year.

Diseases and pests *P. speciosa* has a number of pests in common with other leguminous trees and shrubs. The stem and bark borers *Xystrocera festiva* and *Cossus subfuscus* can cause extensive damage, even death of the tree, particularly at lower elevations in Java. Other pests are the pod borers *Cryptophlebia ombrodelta* and *Mussidia pectinicornella* and the caterpillars of the leaf feeders *Polyura hebe, Eurema blanda* and *E. hecabe*. Commercial plantings in Java are sometimes sprayed with insecticides, a rather hazardous undertaking for the applicant because of the height of the tree. The seeds are also eaten by squirrels (*Callosciurus*).

Yield Individual tree yields vary from 200–5000 pods/year. A harvest of 1000 pods/tree per year is considered satisfactory.

Handling after harvest Seeds can be dried in the sun to improve storability and to facilitate transport over long distances. A small canning and deep-freeze industry has also developed in the region. Industrial processing requires great uniformity with respect to size, colour and age of the seeds.

Genetic resources and breeding No germplasm collections are known to exist in the region, and no breeding programmes are carried out.

Prospects The apparent insufficient supply of petai seeds on local markets to satisfy the demand justifies investigations to increase the cultivation of *P. speciosa* trees. Research should focus on cultivation techniques and on improvement of seed size and taste. The availability of 6 other *Parkia* species in the region certainly widens the scope for successful selection and maybe breeding programmes. Germplasm collection is urgently needed.

Literature |1| Bamroongrugsa, N., 1981. Sator: plant with the bright future. Science Journal, Prince of Songkla University, Patani, Thailand 4(1): 25–31. |2| Bamroongrugsa, N., 1988. Protein- and vitamin-rich plants. Paper presented at the Seminar/Workshop on Asian food, nutrition and rural development extension at Haadyai, Sangkla, Thailand, April 18–27, 1988. |3| Nielsen, I.C. & Santisuk, T., 1985. Leguminosae-Mimosoideae. Parkia. In: Smitinand, T. & Larsen, K. (Editors): Flora of Thailand. Vol. 4(2). The Forest Herbarium, Royal Forest Department, Bangkok, Thailand. pp. 134–138. |4| Sastrapradja, S. & Djajasukma, E., 1979. Keanekaragaman contoh petai (Parkia speciosa) dari Padang (Sumatra Barat) [Variation in P. speciosa samples from Padang (West Sumatra)]. Berita Biologi [Biological News] 2(5): 87–89. |5| Soeparma Satiadiredja, 1950. De teelt en het gebruik van Indonesische groenten en toekruiden [The cultivation and use of Indonesian vegetables and condiments]. Wolters, Groningen, the Netherlands. pp. 85–86. |6| Suhaila Mohamed & Sabturiah Sulaiman, 1984. Chemical constituents of petai (Parkia speciosa Hassk.). In: Mohammad Md. Ali & Lim Eng Siong (Editors). Proceedings of the symposium on vegetables and ornamentals in the tropics, October 27–28, 1982. Agricultural University of Malaysia, Serdang, Selangor, Malaysia. pp. 231–238.

H. Wiriadinata & N. Bamroongrugsa

Pilea Lindley

Coll. bot. 1: t. 4 (1821).
URTICACEAE
$x = 12$

Major species and synonyms
- *Pilea glaberrima* (Blume) Blume, Mus. Bot. Lugd. Bot. 2: 54 (1856), synonym: *P. smilacifolia* (Wallich ex Voigt) Weddell (1854).
- *Pilea trinervia* Wight, Icon. pl. Ind. Orient. 6: 9,

t. 1973 (1853), synonym: *P. melastomoides* (Poiret) Weddell (1854).

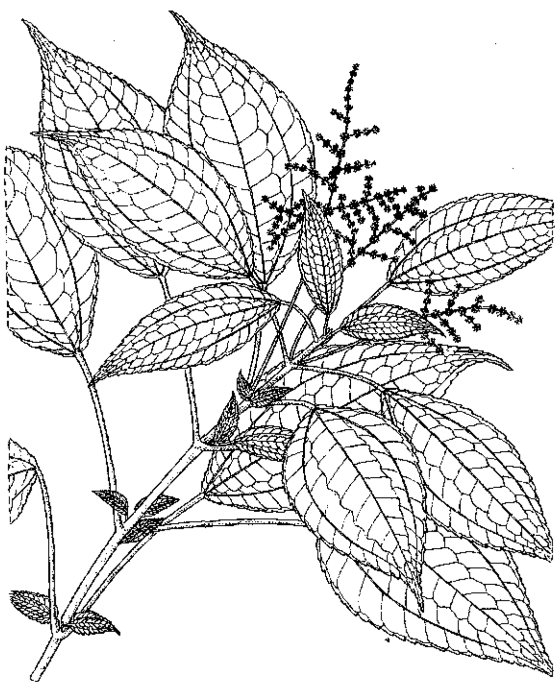
Vernacular names Pilea (En). Indonesia: pohpohan (West Java).

Origin and geographic distribution *P. glaberrima* is known from the eastern tropical Himalaya and from Java. *P. trinervia* has a wide distribution, from India and Sri Lanka to Taiwan, Japan, the Philippines and Indonesia.

Uses Some *Pilea* spp. are grown for their ornamental foliage, but *P. trinervia* and *P. glaberrima* constitute much-relished green vegetables in parts of Indonesia (Java, Sumatra). The leaves of these aromatic herbs are by preference eaten raw with a sauce of capsicum pepper, sometimes steamed, as a side-dish with rice. They are occasionally planted as ornamental or hedge plant.

Production and international trade The leaves of pilea are mainly gathered from the wild. Cultivation only occurs on a small scale, mainly in home gardens. In West Java it is common on local markets, even in supermarkets.

Botany Robust, erect, monoecious or dioecious herbs or undershrubs, 0.5–2 m tall, without stinging hairs. Leaves opposite, distichous; petioles 1–10 cm long; leaf-blade oblong-lanceolate or elliptical, 5–25 cm × 1.5–10 cm, base cuneate or obtuse, apex acuminate, more or less caudate; 3 prominent basal nerves extending near to apex; cystoliths usually linear, sometimes punctate. Inflorescence a lax or dense, copiously branched, axillary cyme; flowers male or female; in monoecious plants the lower inflorescences bear female flowers and the upper ones male flowers; flowers white or greenish-white; male flowers usually 4(–5)-merous, stamens as many as tepals; female flowers with 3 subequal tepals. Fruit an achene, oblique, compressed, about 1 mm long.



Pilea trinervia Wight – flowering and fruiting shoot.

- *P. glaberrima*. Erect herb or undershrub, up to 1.2 m tall. Leaves elliptical-oblong, 6–25 cm × 2–8 cm, entire or with some remote teeth above the middle, long acuminate, glabrous; cystoliths punctate, petiole 1–5 cm long. Inflorescence 3–10 cm long, peduncle shorter than petiole.
- *P.trinervia*. Erect herb, 1–2 m tall. Leaves ovate-oblong, 6–20 cm × 2–10 cm, serrate; cystoliths linear, petiole 1–6 cm long. Inflorescence 5–30 cm long, peduncle longer than petiole.

Both species can be found in flower year-round.

Ecology Pilea occurs in Indonesia wild at elevations of 500–2500 m, in moist shadowed localities such as forests, forest borders, ravines and watersides.

Agronomy Pilea is said to be not easy to cultivate, being rather specific regarding its habitat. It can be propagated by cuttings or by rooted lateral branches, but seed can also be used. Because the seed is very small, it should be sown in seed boxes and transplanted 3–4 weeks later. For optimal development of individual plants, 0.5–1 m² of space is recommended. Plants can also be spaced 20–25 cm in a row to form a hedge. Usually shoots of about 30 cm length are harvested at intervals which depend on the requirements of the local market.

Genetic resources and breeding There are no *Pilea* germplasm collections or breeding programmes.

Prospects Pilea is a popular green of localized importance, mainly gathered from the wild. Because natural stands are dwindling, germplasm collection and cultivation practices deserve more attention.

Literature |1| Backer, C.A. & Bakhuizen van den Brink Jr, R.C., 1965. Flora of Java. Wolters-Noordhoff, Groningen, the Netherlands. Vol. 2. pp. 40–41. |2| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 721–723. [3] Soedirdjoatmodjo, M.D.S., 1986. Bertanam sayuran daun [Growing leafy vegetables]. Karya Bani, Jakarta, Indonesia. pp. 112–116.

U.W. Mahyar

Polyscias verticillata Stone

J. Arn. Arb. 47: 272 (1966).

ARALIACEAE

$2n$ = unknown

Vernacular names Papua New Guinea: valangur (Pidgin, Kuanua).

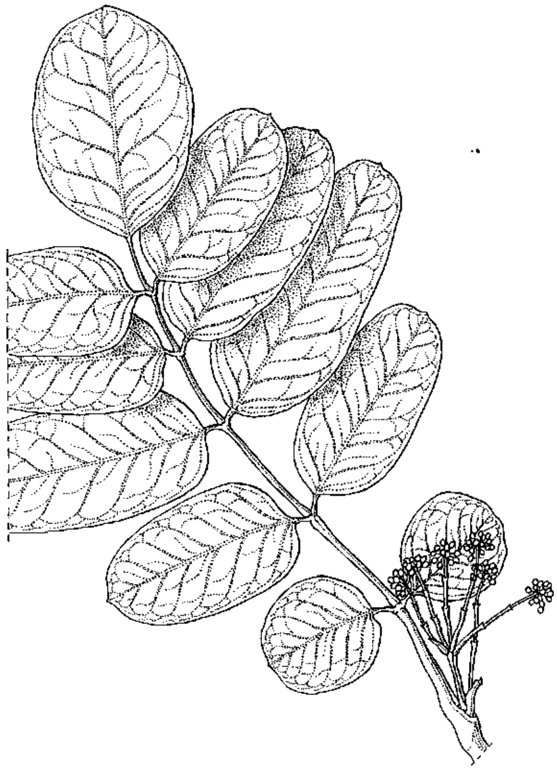
Origin and geographic distribution *P. verticillata* occurs naturally and in cultivation in New Guinea and the Solomon Islands. It is particularly important in the Gazelle Peninsula of New Britain.

Uses The young foliage is eaten fresh or boiled as a green, and as a flavouring for meat and fish. Most of the foliage is still collected from wild trees, but the tree is also occasionally grown as a hedge plant near dwellings.

Production and international trade In the New Guinea islands *P. verticillata* is one of the most important gathered greens, usually oven-roasted wrapped in banana leaves; it is used mainly for home consumption, any surplus being sold in local markets. No production statistics are available.

Properties No information is available on the nutritive composition of *P. verticillata*. The composition of the closely related species *P. fruticosa* (L.) Harms and *P. scutellaria* (Burm.f.) Fosb. might serve as an indication. They contain per 100 g edible portion: water 82–84 g, protein 3.5–3.7 g, fat 0.3–0.4 g, carbohydrates 11.8–13.4 g, vitamin A 2900–5450 IU, vitamin B_1 0.06 mg, vitamin C 29–83 mg, Ca 474–540 mg, P 49–82 mg, Fe 4.0–6.2 mg. The energy value is 225–250 kJ/100 g.

Botany Small, glabrous tree up to 7 m tall, sparingly branched. Leaves arranged spirally towards the ends of the branches, imparipinnate, up to 1 m long; petiole 24–30 cm long, terete with a sheathing base, 6–7 cm long; petiolules 5–20 mm long; leaflets oblong, 16–27 cm × 5–13 cm, base subcordate or truncate, margin entire, slightly revolute or sparsely denticulate, apex acuminate, midrib and lateral veins evident. Inflorescence a large panicle, bearing several long radiating secondary branches in a sub-umbel; secondary branches ca. 50 cm long with numerous 4–7 cm long tertiary branches borne in well-defined verticils and in a terminal umbel; bracts triangular ca. 8 mm long, caducous; umbellules with 10–15 flowers, on pedicels 1–4 mm long; calyx a minute rim; petals 5, violet within, 2.5 mm long; stamens 5, anthers oblong, 1–1.5 mm long; ovary turbinate, 1 mm long, 2-celled; styles 2, persistent in fruit. Fruit a globose drupe, 4–7 mm in diameter when dry, fleshy, purple-black.



Polyscias verticillata Stone – flowering shoot.

P. verticillata is rather aromatic and produces a sweet-scented sticky exudate when wounded.

Three other related *Polyscias* species, which are common ornamental hedge species throughout South-East Asia, are also used as leafy vegetables:
- *P. cumingiana* (C. Presl) Fernandez-Villar (syn. *Nothopanax pinnatum* (Lamk) Miquel, *P. rumphiana* Harms): up to 4 m tall shrub or treelet with imparipinnate leaves up to 1 m long; petiole up to 20 cm with a sheathing base of 5–6 cm; leaflets ovate-oblong or elliptical, 10–30 cm × 2–13 cm, margin entire but sometimes pinnatilobed.
- *P. fruticosa* (L.) Harms (syn. *Nothopanax fruticosum* (L.) Miquel, *P. obtusa* (Blume) Harms): shrub or treelet up to 5 m tall with tripinnate

leaves up to 75 m long; petiole up to 25 cm with a sheathing base of 5 cm; leaflets very variable, oblong or linear-lanceolate, 1–12 cm × 0.5–4 cm, deeply serrate or lobed to irregularly pinnatisect.
- *P. scutellaria* (Burm.f.) Fosb. (syn. *Nothopanax scutellarium* (Burm.f.) Merrill, *Nothopanax cochleatum* (Lamk) Miquel): shrub or treelet up to 6 m tall with simple or trifoliolate leaves variable in size; petiole up to 6(–28) cm with a sheathing base of 1–6 cm; leaf or leaflets rotund or reniform, up to 8(–28) cm in diameter, margin serrate or sublobed; forms with variegated foliage are also in cultivation.

Ecology *P. verticillata* occurs naturally in lowland forest and near beaches, but its use has also been recorded for the highlands of Papua New Guinea, up to 1200 m altitude. It grows well under shade (coconut palms) or in the open.

Agronomy In nature, seeds are readily produced and spread by birds. Spontaneous seedlings are sometimes collected and used as planting material. Propagation by stem cuttings is easy and commonly practised.

Genetic resources and breeding No germplasm collection and breeding have been undertaken.

Prospects More information is needed to determine whether useful applications other than as a leafy vegetable or as flavouring warrant more extensive cultivation.

Literature |1| Department of Primary Industry, 1983. Leafy vegetables. Farming notes 30. Department of Primary Industry, Port Moresby, Papua New Guinea. pp. 8–9. |2| Philipson, W.R., 1979. Polyscias. In: van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 9. Kluwer Academic Publishers, Dordrecht, the Netherlands. pp. 72–86. |3| Stone, B.C., 1966. Polyscias verticillata (Araliaceae), a new species from the Solomon Islands. Journal of the Arnold Arboretum 47(3): 270–272. |4| Unus Suriawiria, 1987. Lalab dalam budaya dan kehidupan masyarakat Sunda [Lalab in the culture and life of Sundanese society]. Granesia, Bandung, Indonesia. 129 pp.

E.A. Widjaja

Portulaca L.

Sp. pl.: 445 (1753); Gen. pl., ed. 5: 204 (1754).
PORTULACACEAE

x = unknown. *P. oleracea*: $2n$ = 18, 36, 45, 54 (a polyploid complex); *P. quadrifida*: $2n$ = 48

Major species and synonyms
- *Portulaca oleracea* L., Sp. pl.: 445 (1753), synonyms: *P. oleracea* L. ssp. *oleracea*, *P. oleracea* L. ssp. *sativa* (Haw.) Schübl. & Mart. (1834).
- *Portulaca quadrifida* L., Mant. pl. 1: 73 (1767).

Vernacular names
- *Portulaca oleracea*: Purslane (En). Pourpier (Fr). Indonesia: gelang, krokot (Java), re-sereyan (Madura). Malaysia: gelang pasir, segan jantan, rumput beremi. Philippines: golasiman (Tagalog), ngaluk (Ilocano), alusiman (Bicol). Cambodia: maông dâb phkaa. Laos: taa kôngz, biaz. Thailand: phakbia-yai (central), phakbia-doklu-ang. Vietnam: rau sam.
- *P. quadrifida*: Single-flowered purslane (En). Indonesia: kremi, gelang pasir. Malaysia: rumput segan. Philippines: sayikan (Tagalog), marangalog (Ilocano). Thailand: phakbia-nu (central), phakbia-lek.

Origin and geographic distribution *Portulaca* is a genus of about 40 species, mainly tropical and subtropical in distribution. In South-East Asia 5 species occur. *P. oleracea* is a cosmopolitan weed (wild and cultivated) whose origin is unknown. Mexico and Australia are considered to be centres of diversity. The cultivated forms probably originated in the Old World. *P. quadrifida* is a pantropical weed (wild and rarely cultivated) whose origin is also uncertain. It does not occur in Australia or in the Pacific east of Samoa.

Uses Purslanes are believed to be among the earliest vegetables of mankind. The leaves and young shoots can be eaten raw. They have a mild pleasant flavour and are frequently used in salads. They can also be cooked and consumed as a spinach dish. It is a good feed for pigs, chickens, and birds like canaries. Large forms are sometimes planted as ornamentals.
P. oleracea is included in the World Health Organization's list of most used medicinal plants. The general uses are as diuretic, to treat rheumatism and gynaecological diseases, as a sedative, analgetic and cardiotonic, to treat fever, disorders of the urinary tract, worm diseases, as tonic and choleretic, to treat dysentery, and to apply externally to ulcers, eczema and dermatitis. Experimentally it has been shown to have no anti-cancer activity, but to have a definite anti-viral, anti-bacterial, anti-fungal action, to be a sedative, and to lower levels of glucose in the blood. *P. quadrifida* is used less widely but has similar medicinal applications.

Production and international trade Most purslane in South-East Asia is gathered from naturally occurring stands. Some *P. oleracea* is produced commercially in European countries. No production or trade statistics are available.

Properties Per 100 g edible portion, *P. oleracea* contains: water 92 g, protein 1.7 g, fat 0.4 g, carbohydrates 3.8 g, Ca 103 mg, P 39 mg, Fe 3.6 mg, vitamin A 2550 IU, vitamin B_1 0.03 mg, and vitamin C 25 mg. The energy value is 88 kJ/100 g.
Both species may contain oxalates in toxic quantities, which may cause death in livestock. In some soils they also tend to accumulate nitrates and thus should be consumed in moderate quantities.
The entire plant of *P. oleracea* contains the alkaloid norepinephrine. The red pigments are acylated betacyanins. The 1000-seed weight is 0.4–0.5 g.

Description Mostly succulent, copiously branched herbs. Leaves opposite or spirally arranged, linear to orbicular, in most species with axillary hairs. Flowers in (1–)2–30-flowered, terminal capitula; receptacle funnel-shaped, mostly with hairs or scales in the axils of the bracts, surrounded by a whorl of 3–30 involucral leaves; sepals 2, occasionally keeled or hooded, persistent or caducous with the petals, stamens and style; petals 4–6(–8), usually obovate, occasionally emarginate or mucronate; stamens 4 to numerous, arranged in 1 whorl; ovary half-inferior, style with 2–18 arms. Fruit a capsule with a deciduous circumscissile operculum. Seeds numerous.

- *P. oleracea*: erect or ascending annual herb, up to 50 cm tall. Leaves obovate to spathulate, 2–40 mm × 1–20 mm, axillary hairs inconspicuous, up to 1 mm long. Capitula 2–30-flowered, involucral leaves 2–8, sepals carinate, up to 6 mm × 6 mm; petals (4–)5, broadly obovate, up to 7 mm × 6 mm, yellow; stamens 7–10(–15); style usually with 5 arms. Fruit ovoid, ca. 4 mm × 3 mm. Seeds 0.5–1.2 mm in diameter, granulate; testa cells stellulate with many fine tubercles.
- *P. quadrifida*: creeping herb, rooting at the nodes; nodes with a whorl of hairs. Leaves all opposite, elliptical to cordate, 2–20 mm × 1–7 mm, axillary hairs 5 mm long. Capitula 1(–3)-flowered, involucral leaves 4; sepals ca. 3 mm long; petals 4, obovate, up to 5 mm × 4 mm, yellow; stamens 8 or 12; style usually with 4 arms. Fruit obovoid, 2–3.5 mm long. Seeds 0.8–1 mm in diameter; testa cells elliptical, radially arranged, surface convex or with a tubercle.

Portulaca oleracea L. – flowering and fruiting plant.

Growth and development *P. oleracea* completes its life cycle in the tropics in 2–4 months. Early growth is slow but accelerates after 2 weeks. It flowers early and year-round. Self-pollination in the bud is the rule. Capsules ripen in 7–12 days from flowering. Purslanes are not considered very harmful weeds because of shallow rooting; nevertheless, *P. oleracea* is often listed as one of the world's worst weeds. They are easily dispersed by running water. Seeds are easily spread by wind, water, with crop seeds or through bird droppings.

Other botanical information *P. oleracea* is a very variable species, the variability also being expressed by the existence of diploid, tetraploid and hexaploid populations. Up to ten subspecies have been distinguished, mainly based on seed size and seed-coat cell morphology, but a convincing classification, including all existing populations of the world, is still lacking. For a long time the species has been subdivided into two subspecies or varieties: ssp. *oleracea* (synonyms: var. *sylvestris* (Mont.) DC., ssp. *sylvestris* (Mont.) Celak) for the wild diploid or tetraploid forms; and ssp. *sativa* (synonym: var. *sativa* (Haw.) DC.) for the cultivated forms, being hexaploid with $2n = 54$. The cultivated forms, which usually have taller plants and larger seeds, can best be distinguished botanically at cultivar level. The existence of numerous intermediate forms raises doubts about the value of classification into subspecies.

P. quadrifida is often confused with *P. pilosa* L. (rose-flowered purslane), also a very variable pantropical weed, sometimes used as ornamental plant. *P. pilosa* has spirally arranged leaves, obovate to linear, up to 30 mm × 4 mm; petals 4–6, pink, red to yellow, stamens 10–75, style arms 4–8.

Ecology Both species are common weeds throughout the warmer parts of the world. Because *P. oleracea* is more tolerant of lower temperatures, it occurs in Java up to elevations of 1800 m, whereas *P. quadrifida* is restricted to the lowlands. They are often involuntarily introduced by the agency of man and readily occupy newly disturbed areas and cultivated fields. Like *Amaranthus* L., the genus *Portulaca* is characterized by the C4-cycle photosynthetic pathway, which means a high photosynthesis at high light intensity and temperatures. Fresh seeds need light for germination, but this requirement disappears in older seeds. Generative development seems not to be influenced by photoperiod. The purslanes are tolerant of a wide range of soils but they prefer sand or sandy loams. In *P. oleracea*, populations are often adapted to certain climatic and edaphic conditions. Diploid populations often grow as halophytes in coastal areas, tetraploids are found in the widest range of latitudes and altitudes, and hexaploids are found mainly at high latitudes and altitudes.

Agronomy Under natural conditions, purslanes generally perpetuate by reseeding, but stem fragments also easily re-root after being cut. In cultivation, propagation is also by seed. Seeds are very small, and they are usually mixed with sand before being broadcast or direct-seeded in rows. Because purslane is shallowly rooted and a crop of short duration, the topsoil should be of good fertility. There is little information on diseases and pests. Damping-off of young seedlings is a common problem.

When cultivated commercially, purslanes can be harvested by uprooting or by 2–3 successive cuts. The first cut is 3–4 weeks after sowing, and subsequently at intervals of 2 weeks. After $1^1/_2$–2 months, flowering interferes with quality.

Top yields in Europe are about 50 t/ha per crop or 2–2.5 kg/m^2 per cutting round. In the tropics yields of 12–17 t/ha have been reported.

Purslane can be stored for 3–5 days at 0–1°C and high relative humidity.

Genetic resources and breeding The wide distribution of the *Portulaca* species points to great genetic flexibility that rapidly permits adaption to new environments. Large variation is available in natural populations, but no germplasm collections exist. Some improved cultivars with larger leaves have been selected for vegetable use. Green- and yellow-leaved types are listed in European seed catalogues.

Prospects *P. oleracea* is decreasing in importance in temperate areas, but it might become a rather popular vegetable in tropical areas. More information on the extent of the utilization of purslanes in various parts of South-East Asia would be useful. There is a need for higher yielding cultivars with good market quality.

Literature |1| Danin, A., Baker, I. & Baker H.G., 1978. Cytogeography and taxonomy of the Portulaca oleracea L. polyploid complex. Israel Journal of Botany 27: 177–211. |2| Dharma, A.P., 1987. Indonesian medicinal plants. Balai Pustaka, Jakarta, Indonesia. pp. 81–82. |3| Fritz, D., Stolz, W., Venter, F., Weichmann, J. & Wonneberger, C., 1989. Gemüsebau [Vegetable growing]. 9th revised edition. Ulmer, Stuttgart, Germany. pp. 316–317. |4| Geesink, R., 1971. Portulacaceae. In: van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 7. Noordhoff International Publishing, Leyden, the Netherlands. pp. 121–133. |5| Holm, L.G., Plucknett, D.L., Pancho, J.V. & Herberger, J.P., 1977. The world's worst weeds: distribution and biology. East West Centre, University Press, Hawaii, United States. pp. 78–83. |6| Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G., 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. pp. 490–491.

S. Susiarti

Psophocarpus tetragonolobus (L.) DC.

Prodr. 2: 403 (1825).

LEGUMINOSAE

$2n = 18$

Synonyms *Dolichos tetragonolobus* L. (1759), *Botor tetragonolobus* (L.) O. Kuntze (1891).

Vernacular names Wing(ed) bean, asparagus pea, goa bean (En). Pois carré, haricot ailé (Fr). Indonesia: kecipir. Malaysia: kacang botor. Papua New Guinea: asbin, bin (Motu). Philippines: kalamismis, sigarilyas, kabey. Burma: pe-saung-ya, hto-pong, ku-bemya. Cambodia: prâpiëy. Laos: thwàx ph'uu. Thailand: thua-phu. Vietnam:

d[aaj]u r[oof]ng, d[aaj]u kh[ees].

Origin and geographic distribution East Africa, north-eastern hill tracts of India and Papua New Guinea have been variously suggested as centres of origin, but Indochinese-Indonesian and East African centres of origin have also been proposed. Centres of greatest diversity are located in Indonesian and Papua New Guinea islands. Burma and Papua New Guinea appear to be the foci of domestication. Here winged bean is cultivated on field scale. Before the recent recognition of its potential it was grown as a horticultural plant in East Africa, parts of India, Sri Lanka, Thailand, Indo-China, Malaysia, Indonesia, Philippines and a few Pacific islands. More recently it has been introduced to almost all tropical areas of the world as well as to some subtropical areas.

Uses Traditionally, green pods have been widely used as a vegetable in South-East Asia. In Papua New Guinea tubers are used in the highlands; young leaves and flowers are eaten as a salad. Tubers are also used in Burma. More recently the nutritional value of dry seeds has been recognized: it is similar to soya beans (*Glycine max* (L.) Merrill) and they can be put to similar uses. Winged bean flour can be used as protein supplement in bread-making. Seeds can also be utilized for making edible oil, milk, and traditional South-East Asian delicacies such as tempeh, tofu and miso. The whole plant as well as processed seeds offer excellent animal feed.

Production and international trade Traditionally, winged bean has only been grown for domestic consumption and local markets on a small scale. No national or international production data are available. Large-scale planting of trellised winged bean in Thailand seems promising.

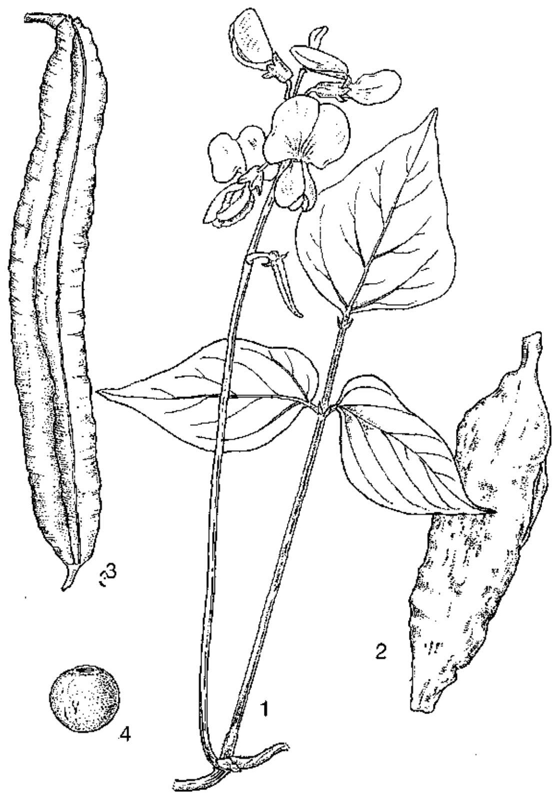
Properties Immature green pods contain 1–3% protein and compare favourably with other leguminous vegetables of the tropics. They are a rich source of calcium, iron and vitamin A. Leaves are nutritionally important containing 5–7% protein and large quantities of vitamins A and C, and minerals.

The mature seed is nutritionally the most interesting part, containing per 100 g edible portion approximately: water 11 g, protein 33 g, fat 16 g, carbohydrates 32 g, fibre 5 g and ash 3 g. The energy value averages 1697 kJ/100 g. It compares favourably with soya bean. The amino-acid spectrum is also similar to that of soya bean, although it may be a little higher in lysine and leucine. The sulphur-containing amino-acids methionine and cystine are the first limiting amino-acids, tryptophane and valine the second. The oil resembles that of groundnut (*Arachis hypogaea* L.). Oleic and linoleic acids make up about 67% of the total fatty acid component and saturates make up 29%. The saturated/unsaturated fatty acid ratio is 1 : 3. The oil is reasonably stable and tocopherol content is high. The oil is easily refined. Amongst minerals, phosphorus and zinc occur in favourable quantities and calcium content is similar to soya bean. Thiamine and riboflavin are present in amounts comparable with other grain legumes.

The 1000-seed weight is about 250 g.

Tubers contain 8–10% protein on fresh weight basis. However, essential amino-acids occur in low proportions. They are rich sources of carbohydrates (30%), calcium and phosphorus.

Description A perennial vine, usually grown as an annual. Roots numerous, with long lateral roots running horizontally at shallow depth, and some becoming thick and tuberous. Stems twining, 2–4 m long, ridged and glabrous. Leaves trifo-



Psophocarpus tetragonolobus (L.) DC. – 1, flowering shoot; 2, tuber; 3, fruit; 4, seed.

liolate; leaflets generally (broadly) ovate, 8–15 cm × 4–12 cm, entire, acute, with small, 2-parted stipules. Flowers 2–10, in axillary 5–15 cm long racemes; calyx campanulate, with 5 short, rounded teeth, green to dark purple; corolla mauve or white, various mixtures of mauve, cream, blue and red, standard 2.5–4 cm long; stamens with 9 filaments fused, 1 free, enclosing the pistil. Fruit a legume (pod), oblong to linear, 6–40 cm × 2.5–3.5 cm, more or less square with 4 smooth to serrated wings 0.3–1 cm wide, rough or smooth, yellow-green, green or, less commonly, cream, occasionally with red flecks. Seed 5–21 per pod, subglobose, about 0.6–1 cm long, brown, yellow, dark tan, white, uniform or variously mottled, glabrous, with a small aril.

Growth and development Seed emergence under field conditions occurs between 5–7 days after sowing. Temperatures around 25°C appear most suitable for germination and growth.

About 2.5 months after sowing at equatorial latitudes, plants start flowering, although some genotypes require as long as 5 months. Pod development is not affected greatly by environmental conditions. Maximum pod length and pod ripening occur about 20 days and 65 days after pollination, respectively.

The fibrous root system with large nodules (up to 1.5 cm in diameter) grows in proportion to the shoots until about 3 months after planting. Then root growth either levels off as the reproductive sinks sequester photosynthates, or accelerates in cultivars and under conditions which favour continued vegetative growth and initiation of tubers. In tuberous cultivars, increases in root dry weight continue beyond the 6th month after planting. Tuberization is known to be enhanced by pruning young shoots and flowers. By the 7th or 8th month, when the shoots senesce, tubers are ready for harvest.

Other botanical information Three other species of the genus *Psophocarpus* DC. may be of interest:

- *P. grandiflorus* Wilczek is naturally distributed from Zaire to Uganda and Ethiopia. This species is possibly the closest to the winged bean.
- *P. palustris* Desv. is naturally distributed from Senegal to Sudan. Recently, it has been introduced to many other parts of Africa and in Asia. It is a traditional food item for some tribes in Zaire. It can be used as a cover crop as well.
- *P. scandens* (Endl.) Verdc. is widely distributed in tropical Africa. It has been suggested as a cover crop and reported to be resistant to diseases which cause great damage to winged bean (e.g. *Synchytrium psophocarpi*).

Ecology Winged bean appears to be best adapted to equatorial climates. In Papua New Guinea and Burma it grows at altitudes up to 2000 m but does not tolerate night frost. Day temperatures in the region of 27°C and nights warmer than 18°C are optimal for growth and reproductive development. The tuber initiation is favoured by cooler conditions. It requires about 1000 mm or more annual rainfall but it is intolerant to waterlogging.

Winged bean is a quantitative short-day plant. Flower induction requires short-day conditions with a critical daylength around 12 hours. The response to daylength varies with genotype, temperature and light intensity. Induction of tubers also requires short days. It thrives on a range of soil types provided that adequate drainage is ensured, and the pH is not lower than 5.5.

Propagation and planting Winged bean is propagated by seed. The crop is grown as a sole crop or intercropped with cereals.

Three broad patterns of cultivation and use can be discerned:

- Field crop tuber production (Burma): the crop is planted on ridges and is not staked. Tubers are harvested before the crop reaches the mature-seed stage.
- Multipurpose horticultural crop (Papua New Guinea): winged bean is the most important leguminous crop grown in the settled valleys of the Papua New Guinea Highlands, at altitudes of 1400–2200 m. 10–20% of the cultivated valley land may be used to grow the crop during June – December. It may be grown as a sole crop in rotation with the staple crop (sweet potato), or in separate blocks within mixed gardens. The plants are staked. All parts of the plant are eaten. When grown for tubers, the flowers and young fruits are removed.
- Minor garden vegetable (South-East Asia): throughout much of lowland South and South-East Asia winged bean plays a minor role as an occasional vegetable in home gardens. One or two plants are planted at the base of fences, stumps or trees over which they sprawl, sometimes to a height of 3–7 m.

Sowing is ideally done at the begining of the rainy season. As a vegetable crop, sowing may be done at any time provided adequate soil moisture is available. Adequate drainage is essential and under wet conditions raised beds may be necessary. Seeding rates depend on the plant vigour. For seed production, about 20 000 plants/ha for vigorous South-East Asian cultivars and 150 000 plants/ha for Papua New Guinea type growth habit should be aimed at. For a tuber crop, the plant density should be about 250 000 plants/ha.

Husbandry Weed control in the first 4–6 weeks is important as the early growth is slow. A well-grown crop should be able to smother weeds. One or two weedings should be done before the plant support system is erected.

Staking plants is necessary. Yield may be reduced to less than half if plants are allowed to trail on the ground. Two meter high stakes or similar supporting systems appear suitable. For a crop raised solely for tuber production, shorter supports may be adequate. Such a crop may also require vegetative and reproductive pruning after the first flowers appear, in order to encourage tuber production.

Under rainfed conditions, irrigation is only needed during periods of prolonged drought. Successful crops have been raised through overhead irrigation in the dry season in Papua New Guinea, when virtually no rainfall occurs.

Winged bean is known to nodulate profusely in symbiotic association with *Rhizobium* strains of the cowpea group. Such strains occur widely in the tropical areas but should problems with nodulation occur, seeds might be inoculated with an appropriate strain. In a well-nodulated crop, nitrogen application is not necessary. However, in soils low in nitrogen, small quantities of ammonium sulphate or urea may be applied. Response to applied phosphorus occurs in most soils and response to applied potassium has been reported in Brazil. Application of P and K in the ratio of 2:1 has been suggested.

Mulching may be needed in dry conditions. There is some evidence that mulching encourages tuber production through reduction of soil temperature.

Winged bean may serve as an important leguminous crop in crop rotations. It may precede a non-leguminous tuber crop or cereal. In Burma, sugar cane following winged bean has been reported to yield twice as much. In the Papua New Guinea Highlands a rotation of sweet potato (wet season) with winged bean (dry season) is commonly practised.

Diseases and pests A number of mycoplasma and virus diseases have been observed. Of these ring spot mosaic virus and necrotic mosaic virus have been positively identified in Ivory Coast. Avoiding sowing seeds from infected crops and locating plots away from the vicinity of other known hosts of viruses may be helpful.

Bacterial blight (*Pseudomonas solanacearum*) has been reported in South-East Asia. Resistant cultivars appear to be the only control measure.

Amongst fungal diseases, false rust or orange gall (*Synchytrium psophocarpi*) is perhaps the most widespread and damaging. Cultivar resistance has also been reported. Dark leaf-spot (*Pseudocercospora psophocarpi*) is also common throughout South-East Asia and Papua New Guinea, and particularly serious in hot and humid areas. Benomyl spray at fortnightly intervals has been found to give good control. Powdery mildew (*Erysiphe cichoracearum*) may be potentially important in relatively cooler areas with dry season but high humidity.

Root knot nematodes (*Meloidogyne* spp.) cause galling of infected roots and stunting and yellowing of leaves. Up to 50% yield may be lost. Flooding for 30–40 days has been recommended as control method in the Philippines.

Amongst insect pests, bean pod-borer (*Maruca testulalis*), *Mylabris afzelli*, *Mylabris pustulata*, *Heliothis armigera* and *Icerya purchasi* have been reported.

Harvesting Fresh and tender pods are harvested as a vegetable when they reach about four-fifths of their full length; this may continue for several weeks. Harvesting a seed crop is complicated because pod ripening occurs over a long period. Mature pods should be collected at regular intervals because pods split and shatter seeds when they remain too long on the plants.

Optimum time for tuber harvesting varies widely. In the Papua New Guinea Highlands, tubers are dug out at first sign of senescence in the crop.

Yield Green pod yields range from 10–15 t/ha but up to 34 t/ha has been reported. Seed yield estimates from farmers' crops are not available. About 1 t/ha is easily obtained. Experimental yields above 2 t/ha have been frequently reported; 4.5 t/ha was recorded in an experiment in Malaysia. Tuber yield in the Papua New Guinea Highlands in farmers' plots was estimated to be 5.5–11.7 t/ha.

Handling after harvest Freshly harvested green pods store poorly and should be marketed within 24 hours. Tubers have been shown to keep in a fresh state for up to 2 months but they are normally consumed or sold soon after harvesting.

Seeds not intended for sowing store better than most grain legumes due to their resistance to common storage insect pests. Seed for sowing should be stored as briefly as possible, since loss of viability may occur in the humid tropics. Seed viability is considerably enhanced by storage at low temperatures and by reducing the moisture content of the seed.

Genetic resources The Indonesian Archipelago and Papua New Guinea are considered to be the centres of greatest genetic diversity. Germplasm has been collected from most parts of South and South-East Asia. However, particular attention is needed for less explored areas such as Burma, Vietnam, Laos and Cambodia. Collections are currently available at the National Bureau of Plant Genetic Resources, New Delhi (India), the Thailand Institute of Scientific & Technological Research (TISTR), Bangkok (Thailand), the Centre for Research & Development in Biology, Bogor (Indonesia), the Pallekele Research Centre, Kundasale (Sri Lanka), the Papua New Guinea University of Technology, Lae (Papua New Guinea), the University of the Philippines, Los Baños (the Philippines), and Southampton University (United Kingdom). Over 1000 accessions may be available in the above collections.

Breeding Winged bean is a semi-domesticated plant and breeding would play a vital role in its development. The breeding objectives depend on the product for which it is raised. As a green vegetable crop, early flowering, high pod yield, pod production over a longer period of time, green pod colour, less fibrousness (reduced parchment layers) and a better taste are desirable. As a pulse crop, important objectives are early flowering, synchronization of pod maturity, senescence at the end of the growing season, high seed yield, low shelling percentage, high protein and oil content depending upon the processing needs, and white seed colour. For a tuber crop, selection for low pod yield, vigorous vegetative growth, high tuber yield, tuber quality factors including high protein, low fibre content and acceptable flavour are relevant. Cultivars for cover cropping should show vigorous vegetative growth, high leaf area index, perennial growth habit, high rate of nodulation and nitrogen fixation, tolerance of waterlogging and ability to compete with weeds.
Psophocarpus scandens and *P. palustris* may be sources for insect resistance but they appear to be genetically distant from winged bean. Attempts to realize interspecific hybridization have been unsuccessful so far.

Prospects Winged bean offers a valuable source of food and feed in subsistence farming. However, large-scale cultivation of winged bean is limited at this stage due to its requirement for plant supports, its tendency to perennial growth, and the occurrence of pod splitting and seed shattering. Although potentially a very useful plant, it should be regarded as semi-domesticated. Active plant breeding with a view to evolve agronomically more acceptable cultivars is crucial for future development. A self-supporting type, or at least one which shows minimum loss of yield when grown without support, is the most urgent breeding objective.

Literature |1| Eagleton, G.E., Khan, T.N. and Erskine, W., 1985. Winged bean (Psophocarpus tetragonolobus (L.) DC.). In: Summerfield, R.J. & Roberts, E.H. (Editors): Grain legume crops. Collins, London, United Kingdom. pp. 624–657. |2| Erskine, W., 1981. Heritability and combining ability of vegetative and phenological characters of winged bean (Psophocarpus tetragonolobus (L.) DC.). Journal of Agricultural Science, Cambridge 96: 503–508. |3| Khan, T.N., 1976. Papua New Guinea: a centre of genetic diversity in winged bean (Psophocarpus tetragonolobus (L.) DC.). Euphytica 25: 693–706. |4| Khan, T.N., 1982. Winged bean production in the tropics. FAO Plant Production and Protection Paper 38, FAO, Rome, Italy. 217 pp. |5| Masefield, G.B., 1973. Psophocarpus tetragonolobus – a crop with a future? Field Crop Abstracts 26: 157–160. |6| PCARR, 1978. The winged bean. Papers presented at the 1st International Symposium on Developing the Potentials of the Winged Bean. Los Baños, the Philippines. 448 pp.

T.N. Khan

Raphanus sativus L.

Sp. pl.: 669 (1753).
CRUCIFERAE
$2n = 18$

Major taxa and synonyms Cultivar group names are proposed here.

- Cv. group Chinese Radish. Synonyms: *Raphanus sativus* L. var. *niger* (Miller) Persoon (1807), var. *hortensis* Backer (1907), var. *longipinnatus* Bailey (1923).
- Cv. group Leaf Radish. Synonyms: *R. sativus* L. var. *oleiformis* Persoon (1807).
- Cv. group Rat-tailed Radish. Synonyms: *R. caudatus* L. (1767), *R. sativus* L. var. *caudatus* (L.) Vilmorin (1925), var. *mougri* Helm (1957).
- Cv. group Small Radish. Synonyms: *R. sativus* L. var. *sativus*, var. *radicula* Persoon (1807).

Vernacular names General: Radish (En). Radis (Fr). Indonesia, Malaysia: lobak. Philippines: labanos (Tagalog), rabanos (Ilocano), alibanos (Pangasinan). Burma: monla. Cambodia: chhaay thaaw. Laos: kaad khaaw. Thailand: phakkat-hua (central), phakkhithut (northern). Vietnam: c[ar]i c[ur]i.

- Cv. group Chinese Radish: Chinese radish, oriental radish, daikon (En). Indonesia, Malaysia: lobak, lobak putih.
- Cv. group Leaf Radish: Indonesia: lobak daun.
- Cv. group Rat-tailed Radish: Rat-tailed radish (En). Radis serpent (Fr). Thailand: phakkhithut (northern).
- Cv. group Small Radish: Small radish, western radish (En). Petit radis (Fr). Indonesia: rades (Javanese), lobak berem (Sundanese).

Origin and geographic distribution The origin of *R. sativus* is not known but the area of maximum diversity runs from the eastern Mediterranean to the Caspian Sea; the variability diminishes gradually from the Caspian Sea to China, and still more to Japan. Radish is a crop of ancient cultivation in the Mediterranean (before 2000 BC), from where it spread to China in about 500 BC and to Japan in about 700 AD. It has now spread throughout the world.

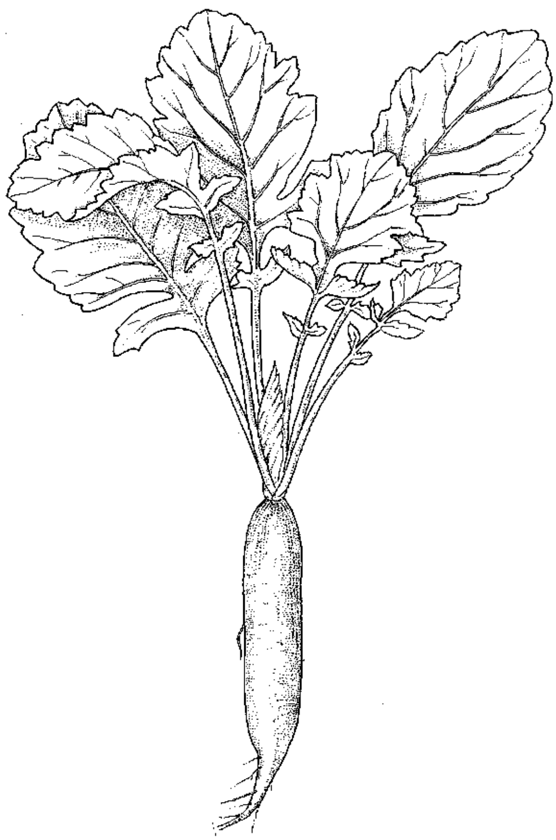
Cv. group Chinese Radish is most important in Japan, Korea, China and South-East Asia. Cv. group Leaf Radish is gaining importance in Europe as forage and green manure. Cv. group Rat-tailed Radish is most important in India and eastern Asia. In South-East Asia it is important in northern Thailand and Burma. Cv. group Small Radish is most important in temperate climates.

Uses Radish is grown mainly for its thickened fleshy root. The western radish (cv. group Small Radish) is pungent and is prized as a relish or appetizer and for adding colour to dishes. The oriental radish (cv. group Chinese Radish), being crisp with mild flavour, plays a much wider role in South-East Asia. The roots are thinly peeled, sliced or diced and put into soups and sauces or cooked with meat. They can be preserved in salt. Sometimes, as in the Philippines, they are eaten fresh, mixed with other vegetables like tomato. Tops (leaves) are eaten as salad or spinach. Seedlings known as radish sprouts are used as greens for appetizers or cooked as spinach. The rat-tailed radish (cv. group Rat-tailed Radish) is grown for the immature seed pods, consumed raw, cooked or pickled. Leaf radish (cv. group Leaf Radish) is mainly grown as green manure and forage (central and western Europe). In South-East Asia (Indonesia) it is sometimes cultivated for the leaves that are used as vegetable.

Production and international trade World production of radish roots is estimated at 7 million t per year, about 2% of the total world production of vegetables. Radish ranks very high in importance in Japan, Korea and Taiwan. Production data from South-East Asia are: Indonesia 27 800 t (1988), Malaysia 1250 t (1988), the Philippines 9000 t (1987), Thailand 32 000 t (1988).

Properties Per 100 g edible portion, the root contains: water 93.5 g, protein 0.6 g, fat 0.1 g, carbohydrates 5.3 g, Ca 32 mg, P 21 mg, Fe 0.6 mg. It contains vitamin A in small quantity, vitamin B_1 0.02 mg, vitamin B_2 0.03 mg, and fair amounts of vitamin C (25 mg) and niacin (0.30 mg). The energy value is 90 kJ/100 g. The 1000-seed weight is about 10 g.

Description Erect, annual, more or less densely hairy herb, 20–100 cm tall; upper part of taproot and hypocotyl swollen, tuberous, globular, cylindrical or tapering, very variable in size, form and weight, red to white, sometimes grey to black,



Raphanus sativus L. – habit cv. group Chinese Radish.

flesh white, sometimes red; stem at first short, growing out towards anthesis, hollow. Leaves alternate, glabrous to sparingly hispid; lower leaves in a radical rosette, petioles 3–5.5 cm long, leaf-blades oblong, oblong-ovate to lyrate-pinnatifid, 3–5-jugate with a round or ovate terminal lobe, 5–30 cm long; higher leaves much smaller, shortly petioled, lanceolate-spathulate, subdentate. Inflorescence a terminal, erect, long, many-flowered raceme; flowers 1.5 cm in diameter, fragrant, white to lilac; pedicel up to 2.5 cm long; sepals 4, oblong-linear, 6–10 mm long; petals 4, spathulate, clawed, 1–2 cm long; stamens 6, tetradynamous; style 3–4 mm long. Fruit cylindrical, up to 10(–30) cm × 1.5 cm, consisting of 2–several superposed joints, lower joint very short and seedless, upper one(s) much larger, terete, spongy and divided into 2–12 one-seeded compartments, indehiscent, with a long, seedless beak. Seed ovoid-globose, about 3 mm in diameter, yellowish.

- Cv. group Chinese Radish: very variable. The smaller forms (South-East Asia) with cylindrical root, 10–25 cm × 4–5 cm, white. Larger forms (China, Japan) can attain a weight of 20 kg, with leaves up to 60 cm long and with 8–12 pairs of pinnae.
- Cv. group Leaf Radish: no swollen roots.
- Cv. group Rat-tailed Radish: fruit can attain 30 cm or more in length.
- Cv. group Small Radish: root globose, ellipsoid or cylindrical, 0.5–4 cm × 0.5–4 cm, red, white, red and white or violet.

Growth and development Radish seeds take about 4 days to emerge at 20–30°C. The taproot may grow to a depth of 1–1.5 m, the lateral roots are few and very slender. The edible part consists of the thickened hypocotyl (cv. group Small Radish) or of the thickened hypocotyl and upper part of the taproot (cv. group Chinese Radish). At first the leaves grow in a rosette, towards anthesis the stem elongates and branches. Flowers are cross-pollinated by insects. Growing time depends on cultivar and desired product. Small radishes can be harvested 3–5 weeks after sowing.

Other botanical information The following wild species, closely related to the cultivated radish, possibly contributed to its origin: *R. raphanistrum* L., distributed in the Mediterranean, western Asia and in Europe; *R. maritimus* Sm., occurring along the coasts of the Atlantic Ocean in Europe, of the Mediterranean Sea and the Black Sea; *R. landra* Moretti ex DC. (considered as an inland form of *R. maritimus*), especially in the western Mediterranean area; *R. rostratus* DC., distributed from Greece eastwards to the Caspian Sea. Sometimes these related species are considered as one species complex named *R. raphanistrum*, with the different taxa classified as subspecies.

R. sativus crosses freely with the related wild species. *R. sativus* is also closely related to several *Brassica* species and to *Sinapis arvensis* L. (charlock), with which it has also been successfully crossed. The taxonomy of *R. sativus* and its related species badly needs a thorough revision.

Radish cultivars are here classified into cultivar groups, but often a practical grouping of cultivars according to growing period, root shape and colour is followed:

- Summer radish (25 days to maturity):
  a) round shape: red skin ('Scarlet Knight', 'Cherry Beauty'), red/white ('Sparkler'), white or yellow ('Golden Globe', 'Snowbelle');
  b) half-long: red/white ('French Breakfast'), white ('Icicle').
- All-season radish (approximately 45 days to maturity): Chinese or daikon type, all elongate, white ('Wu Feng Early', 'Oriental White', local South-East Asian cultivars).
- Winter radish (60 days to maturity):
  a) round shape: white ('Ta May Hua'), black ('Round Black Spanish');
  b) elongate: red ('Chinese Rose'), white ('Minowase', 'Chinese White').

In China red-fleshed cultivars also occur.

Ecology Cool conditions favour optimum growth. Although radish is known as a suitable crop for the highlands or for the cool season at higher latitudes, local cultivars in Indonesia are also quite common at medium elevation (200–700 m), but are rare in the lowlands (< 200 m) where yield is too low. Under short daylength, roots are well-shaped and tops small. Under long days (15 hours) roots are misshapen, tops elongate and early flowering occurs. Low temperatures followed by long photoperiods initiate bolting and development of the flowering stalk. Annual radishes flower after reaching edible size in warm temperatures. White-fleshed cultivars may flower under short days at low elevations, whereas red-fleshed cultivars require long days or elevations above 1000 m. Radish requires light, well-drained, deep soils with pH 6.0–6.5.

Propagation and planting Propagation is by seed. Seed rates are 10–15 kg/ha for Chinese radish and 30–40 kg/ha for cv. group Small Radish. Seed is sown directly on prepared beds in drills. The oriental radish needs a rather wide spacing: 30 cm between rows and 15–25 cm between plants, depending on the cultivar. The western radish requires a narrow spacing of 10–25 cm between rows and is thinned to 2–4 cm between plants in the row. For small areas, seed is often broadcast.

Husbandry In commercial cultivation, radish is normally grown as a sole crop. Intercropping with lettuce is also popular in many areas. An adequate supply of organic material, and a basal dressing of NPK followed by surface dressings of a nitrogenous fertilizer at regular intervals until the roots are mature, are recommended. To remain mild, tender and visually attractive, radish must grow rapidly with plenty of moisture. Water shortage induces root elongation. If growth is checked, the roots become hot-tasting, tough and pithy. Light shading improves root quality during hot, dry weather. Establishment in heavy soils promotes misshapen roots.

Diseases and pests Common foliar diseases are *Cercospora* leaf-spot (*C. brassicicola*) and downy mildew (*Peronospora parasitica*). Serious root diseases in temperate areas are black rot (*Aphanomyces raphani*) and *Fusarium* yellows (*F. oxysporum* f. *raphani*). Club root (*Plasmodiophora*) is increasingly a problem in tropical highlands.
Important pests are flea beetles (*Phyllotreta* spp.) which attack young seedlings, aphids (*Aphis gossypii*, *Lipaphis erysimi*) which cause leaf-curls, and mustard sawfly (*Athalia proxima*) which feeds on the leaves. Root knot nematodes (*Meloidogyne* spp.) are important.

Harvesting Radish must be harvested when fully developed but before the roots are overmature and become tough. It may be harvested with tops or without tops (i.e. leaves topped to 7–10 cm). Western radishes mature in 30–50 days from sowing and can be harvested mechanically, topped, trimmed, and bunched in one operation. Oriental radishes reach the harvestable stage in 50–90 days, and are normally harvested by hand.

Yield Approximately 7–10 t/ha of fresh radish can be achieved for early-maturing cultivars of western radish. Yields of oriental radish vary between 15–20 t/ha; the weight of radishes may reach 2.5 kg/root in Chinese cultivars, and even 10–20 kg/root in Japanese cultivars. Some radishes may grow to a length of 75–100 cm.

Handling after harvest Radishes are washed thoroughly to remove soil and to maintain a fresh appearance, followed by grading and packaging. When sold with tops, they are tied in bunches, and the leaves should be turgid, green, and free from blemishes. Rapid cooling, using crushed ice or cold water to remove heat, helps retain good quality. At high relative humidity and a temperature of 0°C, radish can be stored for 28 days, but at 7°C the storage life is less than 7 days. Roots with leaves attached have half the storage life of topped roots.

Genetic resources Germplasm collections are maintained by NIAR (Tsukuba, Japan), IPB (Los Baños, the Philippines), Department of Agriculture (Bangkok, Thailand), USDA (Fort Collins, United States), and the Crucifer Genetics Cooperatives at the University of Wisconsin (Madison, United States).

Breeding Most farmers in South-East Asia use their own local cultivars of cv. group Chinese Radish. Breeding work of seed companies aims primarily for attractive root shape, colour and mild flavour. Numerous cultivars have been bred by Japanese, Chinese and western seed companies. These modern cultivars have early maturity, resistance to bolting ('Minowase'), attractive root texture (crisp, firm, high solids content), tolerance to diseases such as black rot, *Fusarium* yellows ('Scarlet Knight') and club root ('Saxafire', 'Novitas').
In seed production, open-pollinated cultivars may give a seed yield of 800 kg/ha; an isolation distance of 1000 m is required. Self-incompatibility and male sterility are available for the production of F_1 hybrid seed.

Prospects Radish tolerates a wide range of climatic conditions and is consumed worldwide with a large array of uses. Cultivation in tropical lowlands will increase through the breeding of heat-tolerant cultivars. It will remain a popular vegetable with home gardeners and commercial growers. It is also very suitable as an emergency crop in the case of sudden loss of or damage to the normal food crops: as a consequence of its short crop duration, even the shortest season can accommodate radish production.

Literature |1| Banga, O., 1976. Radish. In: Simmonds, N.W. (Editor): Evolution of crop plants. Longman, London, United Kingdom. pp. 60–62. |2| Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 139–143. |3| Larkcom, J., 1991. Oriental vegetables. The complete guide for garden and kitchen. John Murray, London, United Kingdom. pp. 111–120. |4| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 133–137. |5| Tisbe, V.O., 1967. Carrot, garden beet, radish and turnip. In: Knott, J.E. & Deanon Jr, J.R. (Editors): Vegetable production in South-East Asia. University of the Philippines Press, Los Baños, the Philippines. pp. 305–317.

Kasem Piluek & M.M. Beltran

Rheum ×cultorum Thorsrud & Reisaeter

Norske pl.: 95 (1948).

POLYGONACEAE

$2n = 44$ (tetraploid)

Synonyms *Rheum rhabarbarum* L. (1753) sensu auct. mult., *R. rhaponticum* L. (1753) sensu auct. mult., *R.* ×*hybridum* Murr. (1775) pro parte.

Vernacular names Rhubarb (En). Rhubarbe (Fr). Indonesia: kelembak, talembak (Madura). Malaysia: kelembak.

Origin and geographic distribution The cultivated rhubarb is of unclear hybrid origin. Most probably several parental species are involved: *R. rhabarbarum* (occurring naturally in the highlands of northern China and eastern Siberia), *R. rhaponticum* (occurring naturally in the Rila Mountains in Bulgaria), *R. palmatum* L. (occurring naturally in the highlands of north-western China), and perhaps others. The genus *Rheum* L. has its centre of origin in central and eastern Asia. The medicinal use (strong purgative) of several *Rheum* species (e.g. *R. palmatum*) is very ancient, but the culinary use of rhubarb in Europe dates from the 18th Century only. It is quite certain that the culinary use in Asia is much older.

The cultivation of vegetable rhubarb has mostly spread in the northern hemisphere, especially in West and Central Europe, the United States, Canada, the former Soviet Union and Japan. In South-East Asia rhubarb is cultivated as a vegetable in the cool mountainous regions of Java in Indonesia, Cameron Highlands in Malaysia and around Baguio in the Philippines. It is grown to a limited extent in the mountains of Central and East Africa, India and the West Indies as well.

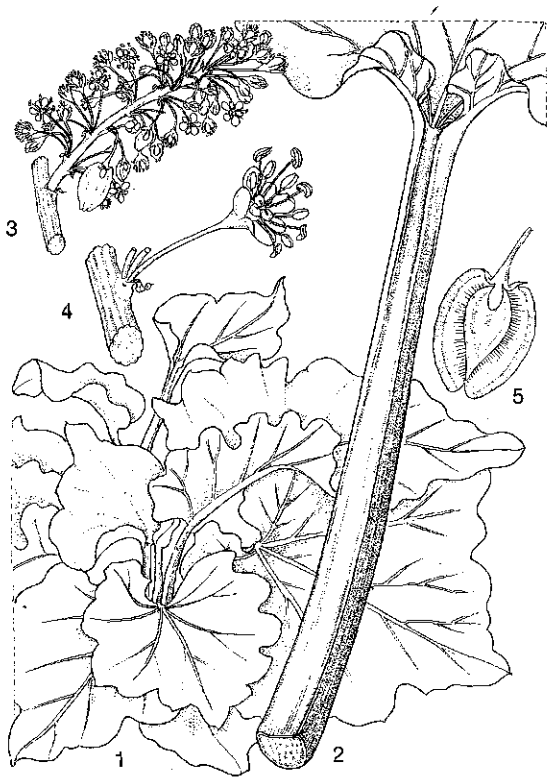
Uses The edible parts of rhubarb are the fleshy petioles which are chopped and stewed with sugar. It is either served as a sweet, used in pies or made into jam.

The roots of vegetable rhubarb are of inferior medicinal value, but have furnished local medicines.

Production and international trade No statistics are available on the production and trade of vegetable rhubarb.

Properties Per 100 g edible portion, rhubarb contains: water 92 g, protein 0.5 g, fat 0.1 g, carbohydrates 2.9 g, fibre 0.7 g and ash 1.3 g. The energy value is 46 kJ/100 g. The pleasant acid taste is caused by the presence of malic, oxalic and citric acids. Rhubarb leaves are poisonous as they contain a high content of anthraquinone and of free oxalic acid. Some fatalities have been recorded from the ingestion of the leaves. The roots also contain anthraquinone.

Description A robust, perennial, tufted herb, up to 1.5 m tall, with a dense rhizome and fleshy roots. Leaves in a radical rosette from the centre of which an erect flowering stem emerges near anthesis; leaf-sheath large, white, thinly membranous; petiole fleshy, on the upperside flat, on the underside obscurely sulcate or rounded with sharp margins, up to 1–1.5 m long and often more than 2 cm in diameter, green often tinged with red or pink; leaf-blade broadly ovate or cordate, 20–50 cm × 15–50 cm, base cordate, margins undulate or crispy and irregularly ciliate, apex obtusely



Rheum ×cultorum Thorsrud & Reisaeter – 1, habit; 2, petiole; 3, inflorescence branch; 4, flower; 5, fruit.

rounded, palmately 3–7-veined, pubescent on the veins beneath; cauline leaves gradually shorter and narrower. Inflorescence a large panicle, with numerous small, bisexual, greenish-white flowers; tepals in 2 whorls of 3; stamens 9; styles 3. Fruit an achene, ovoid, broadly 3-alate, often more than 1 cm long.

Growth and development Under favourable conditions plants may extend to almost 2 m in diameter, hence they need a fairly large open site. In temperate climates plants enter a dormancy period during winter. Low temperatures have a vernalizing effect on flower and leaf formation. Gibberellin may substitute frost to break dormancy. Harvesting should not be carried out during the first six months to enable plants to develop well and to build up reserves. Plants can be harvested thereafter and for many years. Plant clumps should be divided and replanted about every five years, depending on their vigour, to prevent the development of a high proportion of smaller leaves with thin petioles.

Other botanical information The identity of rhubarb is still unknown. The name *R. ×cultorum* is proposed for all commercial cultivated hybrid rhubarb, as the identity of the parents is not known. It seems best to use cultivar names for suitable selections, e.g. 'Early Red', 'Prince Albert', 'Victoria', 'Linneus', 'Oregon Red Giant'. The genus *Rheum* comprises about 50 species; several wild species are used in the same way as the hybrid rhubarb and are occasionally cultivated, e.g. *R. rhaponticum*, *R. rhabarbarum*, *R. compactum* L. (Mongolia, Siberia), *R. emodi* Wallich (Himalaya, also the rhizomes are used medicinally), *R. altaicum* A. Los. (Mongolia, Siberia), *R. palmatum* (mainly for medicinal use of the rhizome), *R. ribes* L. (Iran, Caucasus), *R. wittrockii* Lundstr. (also cultivated as ornamental in Europe, originating from Central Asia), *R. compactum* L. (Mongolia, Siberia), *R. undulatum* L. (Mongolia).

Ecology Rhubarb is well adapted to high rainfall conditions provided drainage is good. It cannot stand waterlogged conditions. The crop is cultivated more frequently in temperate climates, but in the tropics cultivation above 1000 m altitude is possible.

The optimum temperature for growth is from 15–20°C. Diurnal variations in temperature are beneficial (in the traject 4–24°C). Most cultivars are sensitive to high temperatures which may cause the production of spindly, weak petioles. Above 30°C, cultivars that normally exhibit a pink or red petiole colour, usually become green. Plants rarely flower under short-day conditions and at high temperatures. Soils should have a high content of organic material and minerals if yields are to be satisfactory. A moisture-retaining, but well-drained soil is preferable. Although rhubarb tolerates acid conditions, growth is optimal in the pH range 6.5–7.0.

Agronomy Rhubarb is propagated by division of the rhizome into pieces which each have at least one good bud. A new planting should only be started from vigorous healthy mother plants, preferably of named cultivars. Rhizomes should preferably be divided and planted during the dormant phase, in temperate climates in late autumn, in the tropics at the beginning of the rainy season. Propagation from seed is possible but not recommended as the resulting plants are likely to be variable and high quality cannot be guaranteed. Before planting the soil should be deeply cultivated. Planting material is planted in trenches or furrows, about 25–30 cm deep, partially filled with organic manure or compost, 75–90 cm apart, with the buds just showing at the soil surface. If necessary, drainage can be improved by planting into raised beds or ridges. Plants should be kept well watered and free from weeds, particularly while establishing. Flowering stems, which are rare in the tropics, should be removed as they weaken the plant. To stimulate growth, regular applications of NPK are required. Little is known about diseases and pests in the tropics. Rhubarb is susceptible to virus diseases, downy mildew, *Cercospora* leaf-spot, and root rot. Harvesting can be carried out by pulling petioles upwards so that they separate from the rhizome cleanly without snapping. To sustain the plant, 3–4 leaves should always be retained per plant. The basal sheath of the petiole may remain attached or be trimmed, the leaf-blade is removed. One plant may yield 1.5–3 kg of petioles per season or per year. Petioles can be stored for up to 3 weeks at 0–1°C temperature and high humidity.

Genetic resources and breeding A germplasm collection of rhubarb species is present in the Department of Plant Breeding, Swedish University of Agricultural Sciences, Uppsala. Breeding possibilities are good, as different species hybridize easily and promising selections can be propagated vegetatively. For tropical areas breeding objectives are thick straight red petioles that are not stringy and without a strong acid taste, tolerance to drought and waterlogging. Farmers in the highlands of Indonesia use local selections derived from old introductions from Europe.

These have small petioles, possibly because of degeneration through virus infections.

Prospects As vegetable rhubarb is only of local importance in the tropics there is no high prioirity for research or breeding. Cultivars from the temperate regions may continue to serve as a source of planting material. Local virus-free propagation of planting material is needed.

Literature |1| Buishand, T. & Karsten, J.E., 1971. Teelt van rabarber [Cultivation of rhubarb]. Consulentschap in Algemene Dienst voor de groenteteelt in de vollegrond in Nederland, Alkmaar, the Netherlands. 47 pp. |2| Commonwealth Bureau of Horticulture and Plantation Crops, 1970. Annotated bibliography on rhubarb: uses, composition and biochemistry, 1935–1969. Query file no. 5641. East Malling, United Kingdom. 4 pp. |3| Huxley, A., Griffiths, M & Levy, M. (Editors), 1992. The new Royal Horticultural Society dictionary of gardening. Vol. 4. MacMillan, London, United Kingdom. pp. 25–26, 81. |4| Libert, B. & Englund, R. 1989. Present distribution and ecology of Rheum rhaponticum (Polygonaceae). Willdenowia 19: 91–98. |5| Marshall, D.E., 1988. A bibliography of rhubarb and Rheum species. United States Department of Agriculture, National Agricultural Library and Agricultural Research Service Bibliographies and Literature of Agriculture No 62. 377 pp.

I.I.M. Huibers-Govaert

Rorippa Scop.

Fl. Carniol.: 520 (1760).

Cruciferae

$x = 16$; $2n = 32$ (*R. nasturtium-aquaticum*)

Major species and synonyms

- *Rorippa heterophylla* (Blume) Williams, Fl. Trinidad & Tobago 1: 24 (1929), synonyms: *Nasturtium heterophyllum* Blume (1825), *Rorippa dubia* (Pers.) Hara (1955), *Nasturtium indicum* (L.) DC. sensu auct. mult.
- *Rorippa nasturtium-aquaticum* (L.) Hayek, Sched. Fl. Stir. Exs. 3–4: 22 (1905), synonyms: *Sisymbrium nasturtium-aquaticum* L. (1753), *Nasturtium officinale* R. Br. (1812), *Rorippa officinalis* (R. Br.) P. Royen (1982).
- *Rorippa schlechteri* (O.E. Schulz) P. Royen, Mt. Fl. New Guinea 3: 2031 (1982), synonym: *Nasturtium schlechteri* O.E. Schulz (1918).

Vernacular names

- *R. heterophylla*. Indonesia: sesawi langit, sesawi tanah (Sundanese), sudukan (Javanese). Philippines: lampaka (Ilocano), mustapa (Bisaya), amat (Ifugao). Laos: kaad h'oong. Thailand: phakkat-nam. Vietnam: lai ho[af]ng.
- *R. nasturtium-aquaticum*. Watercress (En). Cresson de fontaine (Fr). Indonesia: selada air, kenci. Malaysia: selada air. Papua New Guinea: wara karis. Philippines: pakhoy (Ifugao). Cambodia: krèh-sông. Laos: kaad fàlangx. Vietnam: c[ar]i soong.
- *R. schlechteri*. Highland cress (En). Papua New Guinea: ao.

Origin and geographic distribution

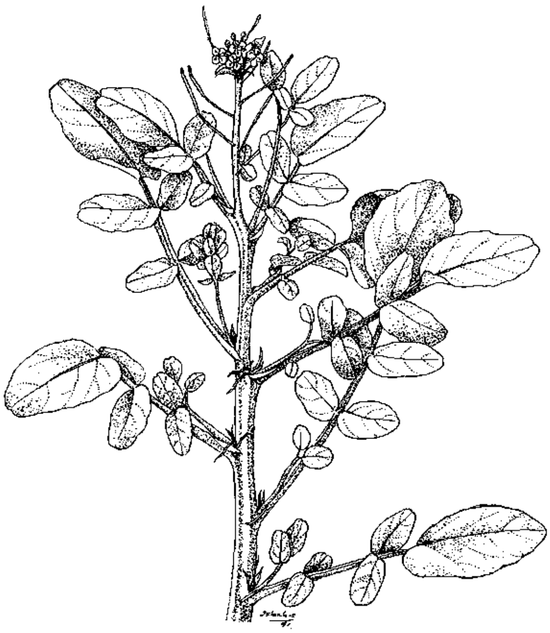
- *R. heterophylla* is indigenous to East Asia from Japan to Burma. It has been introduced into other tropical areas all over the world, including South-East Asia.
- *R. nasturtium-aquaticum* is native to Europe, western Asia and perhaps Ethiopia. It is cultivated and often naturalized in temperate and tropical highland areas throughout the world, including South-East Asia.
- *R. schlechteri* is endemic to Papua New Guinea where it is widely cultivated in the highlands.

Uses Young shoots of all 3 species are usually consumed raw, but they can also be cooked as spinach or in soups. Watercress is sometimes merely used as a garnish or condiment. Used raw it imparts a peppery flavour. Medicinally, watercress was chiefly valued as an antiscorbutic in the past. Steeped in wine or prepared as a syrup, it is also used as a stimulant and laxative. The seeds of *R. heterophylla* are used to cure asthma.

Production and international trade In South-East Asia *Rorippa* species are used and traded locally only. In some areas they are important market vegetables, e.g. in Java (Indonesia). No statistical data are available. Watercress is produced commercially in many western countries.

Properties Watercress is a good source of vitamins and minerals. Per 100 g edible portion it contains: water 93 g, protein 1.7–2.0 g, fat 0.2–0.3 g, carbohydrates 3.0–4.0 g, fibre 0.8–1.1 g, Ca 64–182 mg, P 27–46 mg, Fe 1.1–2.5 mg, vitamin A 2420 IU, vitamin B_1 0.03–0.08 mg, vitamin B_2 0.20–0.27 mg, vitamin C 45–50 mg. The energy value is 70–118 kJ/100 g. The plant yields a pungent, volatile oil, mainly containing phenyl-ethyl isothiocyanate.

Description Annual to perennial, prostrate to erect herb, with taproot, often easily rooting at the stem nodes. Leaves usually pinnatifid to pinnate. Inflorescences terminal racemes, without bracts in the 3 described species, with numerous small



Rorippa nasturtium-aquaticum (L.) Hayek – flowering and fruiting shoot.

bisexual flowers; sepals 4, greenish, spreading; petals 4, yellow or white; stamens 6, distinctly tetradynamous; ovary cylindrical, with numerous ovules; style short with bifid stigma. Fruit a silique, two-valved, dehiscent. Seed numerous, ellipsoid to spheroid, 0.5–1.5 mm in diameter, yellowish to dark brown, finely sculptured.

- *R. heterophylla*. Annual herb, 5–50 cm tall. Stem erect or ascending, one or more from the base, hardly branched. Leaves in a rosette and a few along the stem; lower ones narrowly obovate in outline, 1.5–8 cm long with 1–6 cm long petioles, undivided or lyrate-pinnatipartite with 1–3 pairs of small lateral lobes and a much larger terminal lobe; upper leaves rather few, undivided, narrowly ovate. Racemes 2–10 cm long; flowers with reduced or lacking petals, sepals green; pedicels straight, 2–8 mm long. Fruit linear, 14–25 mm × 0.7–1.3 mm, straight, less than 1.5 mm thick, with seed in one row only. Seed red-brown, rounded quadrangular, finely colliculate.
- *R. nasturtium-aquaticum*. Perennial, much-branched, glabrous, aquatic herb, up to 1 m tall. Stem prostrate to ascending, juicy, hollow, usually rooting at the lower nodes. Leaves petiolate, auriculate, pinnate, oblong in outline, up to 10 cm long; lateral leaflets in 2–9 pairs, sessile, narrowly obovate, elliptical or nearly orbicular, entire to faintly dentate; terminal leaflet similar but larger. Racemes ca. 10 cm long; flowers with white petals; pedicels curved, ca. 1 cm long. Fruit broadly linear, 10–18 mm × 1.5–2.5 mm, more than 1.5 mm thick, often curved and torulose, 7–12 times as long as broad, with seeds arranged in two distinct rows. Seed shiny, red-brown, covered by a distinct reticulum.
- *R. schlechteri*. Annual to short-lived perennial, 15–50 cm tall. Stem solitary, erect, hardly branched. Leaves indistinctly petiolate, auriculate in outline, 1.5–15 cm × 1–3.5 cm, lyrato-pinnate with 1–3 pairs of oblong lateral lobes, 0.2–1.5 cm × 0.1–0.6 cm, and a much larger elliptical-ovate terminal lobe. Racemes up to 15 cm long; flowers with yellow petals; pedicels curved, 3–10 mm long. Fruit inflated, semiglobose, 5–9 mm × 3–6 mm, more than 1.5 mm thick. Seed red-brown, minutely foreolate.

Growth and development *Rorippa* species normally produce abundant seed and multiply rapidly. They are self compatible. *R. nasturtium-aquaticum*, however, seldom flowers in the tropics. For a vigorous growth it demands running water and then the plant becomes tender and sweet. If growth is slow it acquires a bitter taste. When established, the more the tops are harvested the better, as this induces branching. The plants can be harvested for several years, but diseases and weeds may necessitate new plantings more frequently.

Other botanical information In the same distribution area of *R. nasturtium-aquaticum* (natural and naturalized), an allotetraploid species has spontaneously developed ($2n = 64$), named *R. microphylla* (Boenningh.) Hyl. (synonym: *Nasturtium microphyllum* Boenningh. ex Reichenb.). It has small leaves and is not cultivated. A spontaneous triploid hybrid ($2n = 3x = 48$), named *R. ×sterilis* Airy Shaw (= *R. microphylla* × *R. nasturtium-aquaticum*), also occurs occasionally but is sterile and is rarely cultivated.

Ecology *R. heterophylla* occurs on open, moist soils, often on cultivated land, at altitudes of 250–1500 m. *R. nasturtium-aquaticum* occurs naturally in and along running water, and also grows floating in shallow water. It is a long-day plant and very rarely flowers in the tropics. Watercress is most common at higher elevations (above 1000 m), and prefers sandy or gravelly soils, and is rather common in limestone areas, preferring slightly alkaline water (pH 6.5–7.5). It has become a troublesome weed in waterways in New Zealand, forming dense, large mats. *R. schlechteri* also prefers moist or marshy places, but it is cultivated mainly as an upland crop in Papua New Guinea. It is most common at higher elevations, up to 2600 m.

Agronomy *R. nasturtium-aquaticum* is grown from seed (usually imported) or from cuttings. Cuttings root easily in wet sand and in water. Seedlings 8–10 cm tall or cuttings 10–15 cm long are planted out in beds which can be flooded. Paddy fields with not too heavy soils and continuous running water can be used. Plant spacing is usually 10–15 cm either way. Watercress has a high phosphate requirement and nitrate should be applied if the nutrient content of the water is low. Farmers in Indonesia apply urea after each harvest. The major disease is caused by a virus. If the crop is propagated by seed, it will grow virus-free. Other diseases are seldom of economic importance. Flea beetles (*Phyllotreta* spp.), aphids, and caterpillars may cause damage. Some of the pests can be controlled by flooding the crop. Farmers in Indonesia sometimes spray their crop with an insecticide against leaf-eating insects. This is a hazardous practice in view of water pollution and residues on the marketable product.

The first harvest can be taken 4–6 weeks after planting by cutting the 5–10 cm long top ends. This can be repeated at regular 4–6 week intervals for more than a year. Yields of 20 t/ha per cut are not uncommon. Watercress is very perishable and can only be stored for up to 3 days at 0°C and 100% relative humidity.

R. heterophylla and *R. schlechteri* flower and fruit abundantly in the tropics and are propagated by seed. In Papua New Guinea *R. schlechteri* is often planted on sweet potato mounds and harvested repeatedly, starting 4–6 weeks after planting, until the sweet potato canopy is closed. *R. heterophylla* is mainly gathered from the wild.

Genetic resources and breeding There are no germplasm collections of *Rorippa* species. European seed catalogues list watercress, but there are no officially registered cultivars. Some breeding has been done in watercress, e.g. to create an artificial autotetraploid which has thicker and broader leaflets than the diploid but a slower growth rate. Breeding of higher yielding, disease-free cultivars of the 3 *Rorippa* species in South-East Asia seems very possible.

Prospects The popularity of watercress (*R. nasturtium-aquaticum*) is still growing in South-East Asian countries like Indonesia and Papua New Guinea. However, its specific requirements as an aquatic plant needing a lot of clean running water, and its vegetative propagation in the tropics with problems of virus infection, may hamper its development into a major vegetable crop. A detailed comparison with the related 'terrestrial' species (*R. heterophylla* and *R. schlechteri*) would seem to be useful.

Literature |1| Fritz, D., Stolz, W., Venter, F., Weichmann, J. & Wonneberger, C., 1989. Gemüsebau [Vegetable growing]. 9th revised edition. Ulmer, Stuttgart, Germany. pp. 165–167. |2| Howard, H.W., 1976. Watercress. In: Simmonds, N.W. (Editor): Evolution of crop plants. Longman, London, United Kingdom. pp. 62–64. |3| Jonsell, B., 1988. Cruciferae. Rorippa. In: van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 10. Kluwer Academic Publishers, Dordrecht, the Netherlands. pp. 555–560. |4| Powell, J.M., 1982. Traditional vegetables in Papua New Guinea: retrospect and prospect. In: Proceedings of the Second Papua New Guinea Food Crops Conference, July 14–18, 1980, Goroka. Department of Primary Industry, Port Moresby, Papua New Guinea. pp. 64–77. |5| Soedirdjoatmodjo, M.D.S., 1986. Bertanam sayuran daun [Growing leafy vegetables]. Karya Bani, Jakarta, Indonesia. pp. 121–124. |6| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 131–133.

M. Rahmansyah

Rungia klossii S. Moore

Trans. Linn. Soc., Bot. 9: 135 (1916).

ACANTHACEAE

$2n$ = unknown

Vernacular names Rungia (En). Papua New Guinea: kenkaba, tani, moku, ainbe.

Origin and geographic distribution *R. klossii* has been domesticated in the highlands of New Guinea and is probably a native of the same area. It is not known outside Papua New Guinea and Irian Jaya (Indonesia) where wild and cultivated forms occur together.

Uses The leaves are used as a pot herb, often cooked together with the leaves of highland 'pitpit' (*Setaria palmifolia* (Koenig) Stapf). They are sometimes eaten raw. Wild forms growing in the forest are used by hunting parties and collected in times of scarcity.

Production and international trade Rungia is one of the most popular greens in the highlands of New Guinea, and is very common in highland markets. No production statistics are available.

Properties Per 100 g edible portion, rungia leaves contain: water 87.9 g, protein 2.5–5 g, and Ca 272 mg. The energy value is 138 kJ/100 g.

Botany Perennial shrub, up to about 0.8 m tall. Stem branched, internodes pubescent along 2 opposite lines. Leaves opposite; petiole 1–3 mm long; leaf-blade elliptical-lanceolate, 2–4 cm × 1–2.5 cm, basally rounded, apically shortly attenuate, apex obtuse, sparsely pubescent, especially on nerves underneath, dark green when fresh and yellowish along nerves, in a wider zone along midnerve. Inflorescences terminal and axillary spikes, 2–4 cm × 1.5 cm; bracts 4-ranked, 2 neighbouring ranks fertile, 2 sterile, elliptical with conspicuous, often lightly purplish, scarious, ciliate margins, otherwise green, fertile ones pubescent, sterile ones glabrous or very sparsely pubescent; bracteoles as bracts but smaller; calyx 5-lobed, lobes linear-lanceolate, 5.5 mm; corolla white to pale purple, bilabiate with tubular part about 5 mm long, lower lip about 10 mm × 10 mm and shortly 3-lobed, upper lip 5 mm × 5 mm and bifid; stamens 2, anthers bithecous, upper theca muticous below, lower theca shortly spurred.

Rungia klossii S. Moore – 1, habit of flowering plant part; 2, inflorescence.

When grown from cuttings, rungia develops into a bushy shrub with good ground cover. Growth is rather slow during the first few months, but once it matures it recovers rapidly from a plucking or pruning round.

Ecology Rungia mainly grows in the cool climates of the highlands. Although it can be found at sea-level and as high as 2700 m, it is hardly important outside the altitudinal range of 1200–2000 m. It seems to grow well under shade as well as in the open, and prefers fertile, well-drained soils.

Agronomy Rungia is propagated from semi-hardwood cuttings, 15–20 cm long. It is usually planted together with other food plants in sweet potato gardens, forest mixed-crop gardens or kitchen gardens. In pure stands it is grown at a spacing of about 50 cm × 50 cm, and needs a lot of weeding because it grows slowly. A mulch of coffee pulp has been reported to increase yields considerably.

No serious diseases or pests have been recorded on the crop in Papua New Guinea. Shoot tips can be harvested 2–4 months after planting and thereafter at 1–2 monthly intervals for 2 years. Harvested tips are usually small. Yields of 1–2 kg/plant per year can be obtained, or 20–40 t/ha per year at a density of 20000 plants/ha.

Genetic resources and breeding Considerable variation can be observed in wild and cultivated materials. No germplasm collections are being maintained, and no breeding activities are being carried out.

Prospects Very limited information is available on rungia. If it does not receive research attention in order to determine its potential, it is likely to decrease in importance, being replaced by the more productive introduced vegetables.

Literature |**1**| Bourke, R.M., 1981. Some little-known crops of Papua New Guinea. Science in New Guinea 8(3): 164–170. |**2**| Bourke, R.M. & D'Souza, E., 1982. Intensification of subsistence agriculture on the Nembi Plateau: preliminary results. In: Proceedings of the Second Papua New Guinea Food Crops Conference, July 14–18, 1980, Goroka. Department of Primary Industry, Port Moresby, Papua New Guinea. pp. 202–207. |**3**| Powell, J.M., Kulunga, A., Moge, R., Pono, C., Zimike, F. & Golson, J., 1975. The crops grown for food. Agricultural traditions of the Mount Hagen area. University of Papua New Guinea Occasional Paper No 12. pp. 15–32. |**4**| Sillitoe, P., 1983. Roots of the earth: crops in the highlands of Papua New Guinea. Manchester University Press, United Kingdom. pp. 60–62. |**5**| Twohig, A. (Editor), 1986.

Crops: traditional vegetables. Liklik buk, a sourcebook for development workers in Papua New Guinea. Liklik Buk Information Centre, University of Technology, Lae, Papua New Guinea. pp. 77–78.

A.M. Gurnah

Saccharum edule Hasskarl

Flora 25, Beibl. 2: 3 (1842).

GRAMINEAE

$2n = 60–122$, most common are $2n = 70$ and 80

Vernacular names Indonesia: trubus, tebu telur. Papua New Guinea: pit, pitpit.

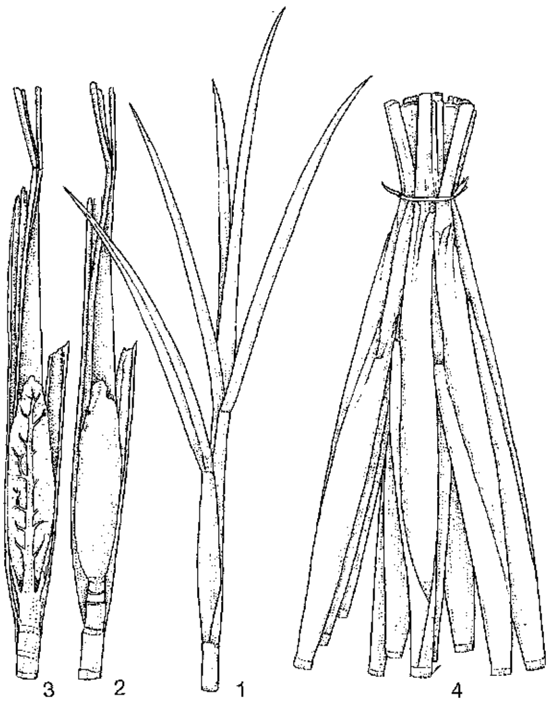
Origin and geographic distribution The origin of *S. edule* is unknown; it only occurs in cultivation. It has very probably been derived from the wild *S. robustum* Brandes & Jeswiet ex Grassl, which is also considered as one of the possible ancestors of sugar cane (*S. officinarum* L.). *S. edule* is cultivated from Borneo and Java through Melanesia to the New Hebrides.

Uses *S. edule* is cultivated for its edible inflorescences. The inflorescences are abnormal in the sense that they remain enclosed within the leaf-sheaths, forming a compact mass about the size of a banana. This mass is relished as a vegetable, either raw, cooked, steamed or roasted. In Papua New Guinea it is an important seasonal food in some areas.

Production and international trade No production figures are available. *S. edule* is produced and consumed locally and traded in local markets only. In Indonesia it is offered for sale in bunches of 10. It is very common in New Guinea and the Moluccas; worldwide it is most important in western Melanesia.

Properties Well-prepared *S. edule* is very tasty. Per 100 g fresh edible portion it contains: water 89 g, protein 3.8–4.1 g, no fat, carbohydrates 6.9–7.6 g, fibre 0.7 g, Ca 10 mg, Fe 0.4–21 mg, vitamin C 21 mg. The energy value is 143–160 kJ/100 g.

Botany Robust perennial herb, tillering or spreading by stolons or rhizomes. Culms cylindrical, large, 1.5–3(–10) m tall, 2–3 cm in diameter, widest at the growth rings just above nodes and root bands; pith hard, with little or no sugar. Leaves in upper part of culm, sheathed; leaf-sheath softly hirsute; leaf-blade oblong, 1–2 m × 2.5–7 cm, on both sides with rather long hairs. Inflorescence abortive, remaining enclosed in sheath of uppermost leaf, consisting of a dense mass of underdeveloped floral primordia, 10–20 cm long.



Saccharum edule Hasskarl – 1, leafy shoot; 2, shoot with young inflorescence (leaf removed); 3, shoot with young inflorescence (longitudinal section); 4, marketed product.

S. edule is exclusively propagated by cuttings or by division of clumps. The cuttings soon tiller and form clumps which continuously increase in size by forming lateral shoots which curve downwards and root in the soil. About 5 months after planting, harvesting of inflorescence masses can start. The economic lifetime of each clump is about 2–3 years.

The identity of *S. edule* is often debated. Probably it does not deserve species status, but the abortive inflorescences obscure characters that would facilitate its identification. In the literature it has been considered as an unusual form of sugar cane (*S. officinarum* L. var. *edule* (Hasskarl) Backer), as a derivative of *S. robustum* because it resembles it in vegetative habit and has the same distribution (cultivation) area, and it has been thought of as a hybrid between *S. robustum* and *Miscanthus floridulus* (Labill.) Warburg. If *S. robustum* and *S. edule* are conspecific, the name *S. edule* has priority. Being a purely cultivated taxon, it could also be named *Saccharum* L. cv. group Edule, thereby disregarding its complex origin.

Various clones differing in morphology (stem colour, leaf form, position of the inflorescence), chromosome number and isoenzyme content are known to exist. They can best be classified and described as cultivars. At least 10 different clones are known in Papua New Guinea.

Ecology Not much is known about the ecological preferences of *S. edule*. *S. robustum* occurs in the hot humid tropics of Melanesia, mostly at low elevations, forming cane brakes along river banks, occasionally in montane valleys up to 2300 m altitude.

Agronomy *S. edule* is propagated by cuttings or by parts of the clump. Cuttings or shoots 0.5–1 m long are planted 2–3 together in mixed crop gardens. They take 6–9 months to develop fully. If not harvested, the inflorescence does not develop further but rots within the leaf-sheath. Too old inflorescences become inedible. It is recommended to renew the plant clumps every 2–3 years.

Prospects Being a nutritious and delicious vegetable, rich in protein, *S. edule* deserves more attention. Extensive germplasm collection is recommended. Further research on cultivation techniques and ecological requirements might reveal that it is an interesting vegetable species for the hot humid tropics, worth being introduced to other areas too.

Literature |1| Backer, C.A. & Bakhuizen van den Brink Jr, R.C., 1968. Flora of Java. Vol. 3. Wolters-Noordhoff, Groningen, the Netherlands. pp. 584–585. |2| Barrau, J., 1962. Les plantes alimentaires de l'Océanie, origines, distibution et usages [The edible plants of Oceania, origins, distribution and uses]. University of Aix-Marseille, Faculty of Sciences, Thesis No 71. pp. 157–158. |3| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 337–338. |4| Powell, J.M., 1976. Ethnobotany. In: Paijmans, K. (Editor): New Guinea vegetation. Elsevier Scientific Publishers, Amsterdam, the Netherlands. pp. 106–134. |5| Whalen, M.D., 1991. Taxonomy of Saccharum (Poaceae). Baileya 23(3): 109–125.

P.C.M. Jansen

Sauropus androgynus (L.) Merrill

Philipp. Bur. For. Bull. 1: 30 (1903).
EUPHORBIACEAE
$2n$ = unknown

Synonyms *Clutia androgyna* L. (1767), *Sauropus albicans* Blume (1825), *S. sumatranus* Miq. (1860).

Vernacular names Star gooseberry (En). Indonesia: katuk, babing (Java), simani (Sumatra). Malaysia: cekur manis. Philippines: binahian (Tagalog). Cambodia: ngub. Laos: hvaan baanz. Thailand: phakwan-ban. Vietnam: rau ng[os]t, b[oof] ng[os]t.

Origin and geographic distribution The exact origin of *S. androgynus* is unknown, but it occurs from India and Sri Lanka to southern China and Indo-China and throughout South-East Asia, mainly in cultivation, but also wild. It has not been reported from New Guinea.

Uses The young shoots and stripped leaves, often together with the flowers and fruits, are consumed raw as well as cooked. When eaten raw, they have a strong characteristic odour and taste sweet. When cooked, they have a very agreeable, slightly acid flavour, and tend to retain a dark green colour and firm texture. In Malaysia, very young shoots without mature leaves are offered for sale as a delicacy. The small, white fruits are sometimes comfited into a sweetmeat.

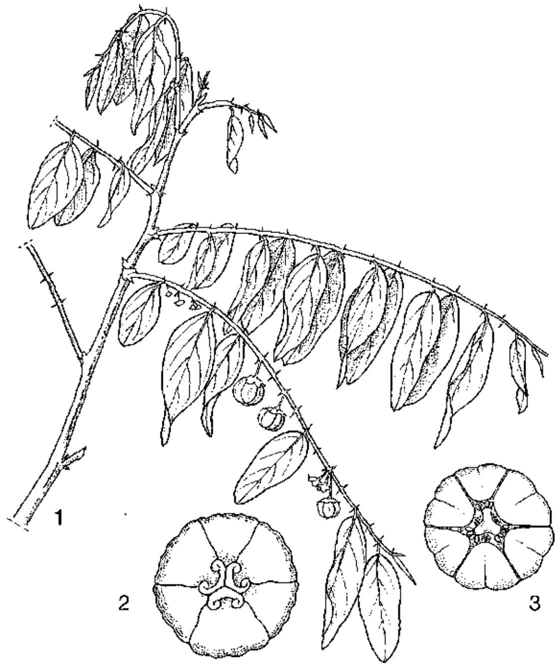
In India, sauropus leaves are also used as a cattle and poultry feed. In traditional medicine, a decoction of the roots is used against fever and urinary problems. The leaves also have medicinal value: prepared as vegetable they are recommended for women after childbirth to stimulate milk production and recovery of the womb. Sauropus is often planted in home gardens as a living fence, serving as a source of vegetable and medicine. The leaves are also used for dyeing foodstuffs, in particular to transfer a green colour to pastry, rice and preserves. The green colour is obtained by rubbing and squeezing the leaves.

Production and international trade Sauropus is a common home garden plant but is also grown in commercial market gardens. No production statistics are available.

Properties Sauropus is a very nutritious vegetable with a higher protein content than most other leafy vegetables. Per 100 g edible portion, it contains: water 79.8 g, protein 7.6 g, fat 1.8 g, carbohydrates 6.9 g, fibre 1.9 g, ash 2.0 g, vitamin A 10000 IU, vitamin B_1 0.23 mg, vitamin B_2 0.15 mg, vitamin C 136 mg, Ca 234 mg, P 64 mg, Fe 3.1 mg. The energy value is 310 kJ/100 g.

It has been reported that consumption of leaves in great quantity may cause pain of the limbs.

Botany An erect, glabrous, perennial, monoecious shrub which can reach a height of 3.5 m, but is kept much lower in cultivation. Branches terete



Sauropus androgynus (L.) Merrill – 1, flowering and fruiting shoot; 2, female flower; 3, male flower.

and flaccid, lateral ones at first tetragonous, with many small short-petioled leaves and persistent stipules. Leaves biseriate, alternate, oblong to orbicular, 2–7.5 cm × 1–3 cm, entire, glaucous, above dark green, often with vague greyish spots, beneath light green. Inflorescence a dense, unbranched, axillary fascicle, first producing 1 or a few female flowers, afterwards several male ones; flowers without corolla, but with more or less intensely red-coloured persistent calyx; calyx of the male flower disciform, 6–10 mm in diameter; stamens 3, connate; calyx of the female flower 6-cleft more than halfway down, lobes 6–8 mm broad; stigma 3-branched, red, each branch bilobed. Fruit a globose to faintly 6-angular capsule, about 1.5 cm in diameter, white or purplish, dehiscing with 3 valves.

Sauropus has an awkward growth habit with long, upright main stems, and a weak tendency to branch. The short lateral branches superficially have the appearance of compound leaves. The shortly pedicelled discoid male flowers are characteristic for the species. Sauropus' flowers year-round in Java and fruiting is usually abundant.

Ecology Sauropus is cultivated in Indonesia and Malaysia from sea-level up to 1300 m altitude, but is most abundant at low elevations. Wild it is common in evergreen forest, clearings, scrub, rocky or waste ground, and roadsides. It grows best in somewhat shady places. It tolerates heavy rainfall and heavy soils, but does best under conditions of good fertility and drainage.

Agronomy Sauropus can be propagated from seeds, which are usually readily available from established plantings, but propagation from stem cuttings is easier and much more common. Somewhat woody cuttings, 20–40 cm long, are planted directly in the field or rooted in a nursery and transplanted one month later. In commercial plantings the distance is 30–40 cm × 30–40 cm. In home gardens, sauropus is usually grown as a hedge and planted closely in the row (10 cm). After establishment, it needs little care apart from pruning to stimulate the growth of new shoots and to maintain the height of the shrubs at about 1 m. It responds well to organic (10 t/ha) and nitrogenous (urea, 200 kg/ha) fertilizers. Diseases and pests are seldom a problem. The crop can be harvested for the first time about 4 months after planting. Subsequent harvests of shoots and leaves are at monthly intervals over a period of several years. After harvest, the shoots are bundled in small bunches and marketed soon, as they wilt rapidly.

The dried roots are often sold for manufacturing traditional medicines.

Genetic resources and breeding No germplasm collection and breeding are in progress.

Prospects Sauropus is one of the most valuable indigenous leafy vegetables in South-East Asia: it is nutritious (but there are some indications of possible antinutritional factors), and it is productive and easy to cultivate. Although grown locally in considerable acreages in commercial gardens, it has not received adequate research attention and very little new information has been generated during the last 50 years.

Literature |1| Airy Shaw, H.K., 1972. The Euphorbiaceae of Siam. Sauropus Bl. Kew Bulletin 26(2): 330–339. |2| Giri, J., Bhuvaneswari, V. & Rajeswari, D., 1984. Changes in the nutritive value of chekkurmenis at different stages of growth. Indian Journal of Nutrition and Dietetics 21(11): 419–423. |3| Martin, F.W. & Ruberté, R.M., 1975. Edible leaves of the tropics. Antillian College Press, Mayaguez, Puerto Rico, United States. pp. 35–37. |4| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 290–292. |5| Soedirdjoatmodjo, M.D.S., 1986. Bertanam sayur daun [Growing leafy vegetables]. Karya Bani, Jakarta, Indonesia. pp. 86–91.

M.H. van den Bergh

Sechium edule (Jacq.) Swartz

Fl. Ind. Occ. 2: 1150 (1800).

CUCURBITACEAE

$2n = 24$, 26 or 28

Synonyms *Sicyos edulis* Jacq. (1760), *Chayota edulis* Jacq. (1780), *Sechium americanum* Poiret (1806).

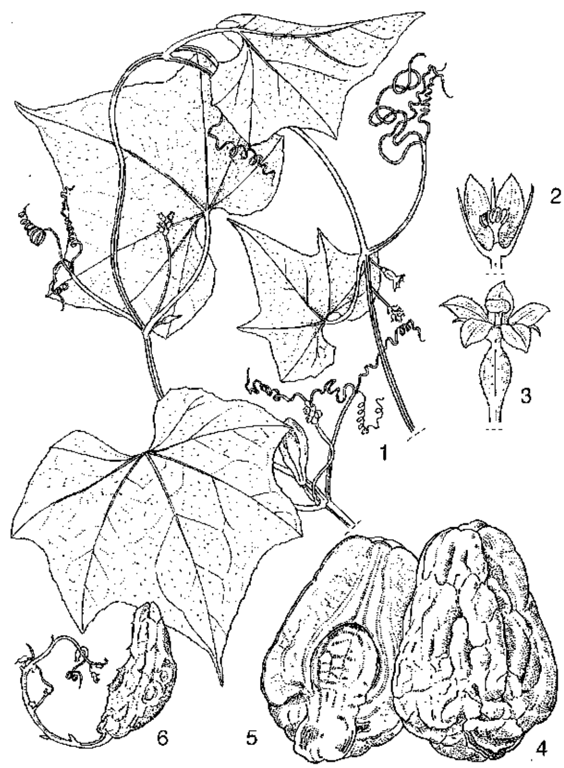
Vernacular names Chayote, vegetable pear (En). Christophine, chouchou, chouchoutte (Fr). Indonesia: labu siam, waluh jepang. Papua New Guinea: choko, sako. Philippines: chayote (Tagalog), sayote (Tagalog, Bicol), hayuti (Ifugao). Cambodia: su-suu. Laos: savëëx, nooy th'ai. Thailand: ma-kheua-kreua, taeng-kariang. Vietnam: su su.

Origin and geographic distribution Putative wild populations of *S. edule* and related wild species are found in Central America, and therefore this region is most likely the centre of origin of chayote. Chayote was already a common cultivated vegetable among the Aztecs in pre-Columbian times. It has now spread throughout the tropics and subtropics, including South-East Asia, but is most important in tropical America. It can hardly be found in South Asia (India) and is not very popular in Africa.

Uses Every part of chayote is useful, but it is mainly grown as a fruit vegetable. Its immature fruits, young leaves and shoots, and tuberous roots are all consumed. The fruits vary in flavour, according to cultivar, from bland to sweetish or starchy. Those of the bland cultivars are also used industrially as a food filler for pastes and sauces and as a substitute for apple in pies and tarts. The starchy tuberous roots are used sometimes in soups and stews and are also candied. The tender young shoots and leaves are a valuable pot herb, especially rich in vitamins A and C, the B vitamins, calcium and iron. It is one of the most important greens in Papua New Guinea. Fruits, shoots and tubers are also used as fodder and forage for pigs, poultry and cattle. Fibres of the stem are used locally to make hats and baskets. In Java the plant is used to shade fish ponds, and in the Philippines it has undergone trials for use in erosion control. The seed is nutlike in flavour and a source of protein.

Production and international trade Chayote is the fifth most important commercial vegetable in Brazil where 170000 t were produced in 1978. Mexico produced ca. 12000 t in 1978. Costa Rica produced less but is the leading exporter: ca. 4600 t in 1982, mainly to the United States, valued at US$ 1.5 million. It is important in all South-East Asian countries as a cheap, easy-to-produce vegetable both for home consumption and for city markets. No statistics are available for South-East Asia; chayote data are usually combined with all other gourds and pumpkins. In the Indonesian highlands it is, in quantity, the most important vegetable produced.

Properties The edible portion of immature fruits of chayote is about 86%. Per 100 g edible portion, they contain: water 93 g, protein 0.9 g, fat 0.3 g, carbohydrates 5.3 g, vitamin A 50 IU, vitamin B_1 0.03 mg, vitamin B_2 0.04 mg, niacin 0.5 mg, vitamin C 11 mg, Ca 19 mg, Fe 0.4 mg, Mg 14 mg, P 20 mg. The energy value is about 109



Sechium edule (Jacq.) Swartz – 1, flowering and fruiting shoot; 2, male flower (longitudinal section); 3, female flower; 4, fruit; 5, fruit (longitudinal section); 6, fruit with germinating seed.

kJ/100 g. The roots contain per 100 g edible portion: water 80 g, carbohydrates 18 g.

Description A monoecious, vigorous, perennial herbaceous vine with a large tuberous root. Stem climbing or sprawling, longitudinally grooved, growing 10–15 m in a single season. Tendrils large, 2–5-branched. Leaves simple, spirally arranged; petiole 3–25 cm long; leaf-blade broadly ovate-circular in outline, 7–25 cm in diameter, base deeply cordate, 3–7-angular or lobed, acute, margins obtusely dentate, scabrid hairy. Inflorescences axillary racemes with small, greenish or cream, 5-merous flowers; hypanthium saucer-shaped, with 10 pouch-like nectaries on the bottom; male racemes with peduncle 6–30 cm long, 10–30-flowered; stamens 5, filaments united; female flowers usually solitary on short pedicels, in same axil as male; corolla ca. 2 mm in diameter; connate style and stigmas, forming a small head. Fruit a one-seeded fleshy berry, variable, commonly pear-shaped, 7–20 cm long, somewhat ribbed, smooth or shortly spiny, dark green to almost white; fruit stalk 2–3 cm long, pendent; pulp white or greenish-white. Seed solitary, ovoid to ellipsoid, 2.5–5 cm long, compressed, white, germinating within the fruit, usually while the fruit is still attached to the plant; in some genotypes seed-coat with fibres radiating into the flesh, in others obsolescent and the flesh fibreless.

Growth and development Chayote is a long-lived perennial, but in cultivation it is recommended to renew it at least every 3 years because of disease problems. The tubers do not develop until the second year, and do not develop well in perpetually wet climates. In regions with a season of arrested growth, they can reach 10 kg in weight and they resemble yam tubers. Flowering starts 1–2 months after germination. Chayote is predominantly cross-pollinated, but is self-compatible. It is a renowned honey-producing plant, loved by beekeepers because it flowers abundantly throughout the year. Fruit development takes 1–2 months after pollination. In good conditions, chayote plants grow profusely and can form a dense foliage cover on trellis, producing hundreds of hanging fruits. The seed germinates in the ripe fruit while still on the mother plant. This phenomenon is called viviparous germination (comparable to viviparity in mangrove species).

Other botanical information The genus *Sechium* P. Browne has long been considered as monotypic with *S. edule* as the only species. Since the 1970s wider genus concepts have been proposed, including 3–9 species, all indigenous to Central America. *S. compositum* (Donn. Smith) C. Jeffrey, occurring in southern Mexico and in Guatemala, is considered the closest wild relative of *S. edule*. Its fruit is bitter and it bears spines along its 5–10 ridges.

Chayote cultivars do not breed true, although it has been observed that cultivars do not segregate significantly from one generation to the next because of the relative isolation of chayote plants from one another when planted in home gardens. When planted together, complete panmixy can be observed. Substantial efforts made at CATIE (Costa Rica) to describe cultivars on the basis of fruit characteristics proved to be of limited relevance because of the extraordinary variability, with continuous variation in almost all the characters. The variable fruit characters include size (7–20 cm long), weight (100–1000 g), colour (continuous range from white to dark green), shape, fruit-wall features (spines, lenticels, grooves and ridges), flavour and texture. Nevertheless, farmers 'classify' the genotypes by a combination of such fruit characteristics. Instead of speaking of cultivars, it seems best to consider those types as landraces or as primitive populations. At least 25 landraces exist in Central America. Commercially grown chayote consists of two types: a medium sized, light-green, smooth, pear-shaped fruit and a small, white, smooth, globular one. Several types can be distinguished in South-East Asia. For example, in West Java (Indonesia) the common type is dark green and almost glabrous, but more spiny and lighter green types can be found. A complete white type, less tender and spiny, is sometimes grown as a botanical curiosity.

Ecology Chayote requires high relative humidity (80–85%), annual rainfall of at least 1500–2000 mm (or irrigation) and average temperatures of 20–25°C (with limits of 12–28°C). It grows best at 300–2000 m altitude. In Java it is abundant in the highlands between 700–1800 m. When planted in the lowlands, it does not produce any fruits. At higher latitudes, it grows and produces well in the lowlands, but the production stops during the hottest months. A daylength of a little more than 12 hours is required to initiate flowering. It is susceptible to frost, drought and wind. Chayote does best in a rich well-drained, rather loose sandy loam. The natural habitats of wild chayote are moist steep hillsides.

Propagation and planting Chayote is propagated by placing a whole fruit on its side in a hollow scooped out at the foot of a trellis support and covering the fruit slightly with soil and farmyard manure. Sometimes up to 4 fruits, already bearing sprouts of 10–12 cm length, are planted in the same pit. More recently, cuttings are being used in Costa Rica to propagate selected genotypes for commercial production on large acreages. The plants are usually spaced 1.5 m apart along a fence or trellis, but when they are allowed to sprawl they need much more room. They grow in trees to a height of over 10 m.

Husbandry A trellis support must be provided for optimum growth. In gardens, plants can be trained over a fence, porch or tree. They are best planted where there is some shelter from strong winds. Chayote requires large quantities of water (ca. 50 mm per week during the growing season) and should be abundantly irrigated in regions of low rainfall and during periods of drought. The incorporation of manure or compost is recommended. In India, ammonium sulphate and superphosphate at the rate of 1 kg and 0.5 kg respectively per pit are applied in two doses before flowering. In some parts of the world, the plants are pruned at the end of the season, leaving only a small portion of about 1.5 m of the stem.

Diseases and pests Chayote is susceptible to several fungal and viral diseases, root-knot nematodes and spider mites. It has been observed in Central Java (Indonesia) that whole plantings of chayote perished through an aggressive mosaic virus infection. Downy mildew (*Pseudoperonospora cubensis*) has been reported to cause damage in Java (Indonesia). Powdery mildew (*Erysiphe cichoracearum*) and *Mycosphaerella* occur on chayote in Central America, but they are not very damaging. The use of pesticides may reduce yield by killing pollinating insects. Because of disease problems, chayote plants are kept in commercial production no more than 3 years.

Harvesting Chayote plants start producing fruits in 3–5 months after planting and a fruit needs 4–6 weeks from pollination to market size (approximately 0.5 kg). The fruits are hand-picked and marketed directly. To harvest tubers, the plant is not necessarily killed. Individual tubers can be carefully harvested, while the plant continues to produce fruits and new tubers.

Yield Production can be seasonal or almost continuous, depending on the climate, and annual yields may vary from 75–300 or more fruits per plant. In commercial plantations, yields of 22–28 t/ha have been reported.

Handling after harvest When fruits are stored in a cool and dark place, sprouting will start after approximately 2 weeks. In cold storage the fruits keep well for several weeks.

Genetic resources Chayote cannot be stored as seed for much longer than one month since it is viviparous, the seed having no dormancy and germinating within the fruit. Long-term maintenance of germplasm collections must therefore be in the form of living plants, or as tissue cultures under slow growth conditions. Germplasm collections are at present held by CATIE (Turrialba, Costa Rica), Chapingo Regional Centre (Huatusco, Vera Cruz, Mexico), INIA (Celaya, Guanajuato, Mexico) and EMBRAPA (Brasilia, Brazil). Genetic erosion of chayote in its region of indigenous cultivation is accelerating as a result of rapidly increasing commercialization and the replacement of landraces by a few improved cultivars.

Breeding Commercial production is limited by some disease problems. A breeding programme for fruit quality and disease resistances is needed, but, logically, private seed companies are not interested in chayote because it is viviparous. A bland cultivar is required for the industrial market and a tasty one for the table vegetable market. Further collection and evaluation of landraces in Mexico and Central America is also required.

Prospects Because of its low energy value, chayote is gaining importance as a dietary food in hospitals and nursing homes. Its use as a food filler for pastes seems to be promising.

Literature |1| Engels, J.M.M., 1983. Variation in Sechium edule Sw. in Central America. Journal of the American Society for Horticultural Science 108: 706–710. |2| Engels, J.M.M., 1984. Chayote: a little known Central American crop. FAO/IBPGR Plant Genetic Resources Newsletter 63: 2–5. |3| Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 339–342. |4| Newstrom, L.E., 1985. Collection of chayote and its wild relatives. FAO/IBPGR Plant Genetic Resources Newsletter 64: 14–20. |5| Newstrom, L.E., 1986. Studies on the origin and evolution of chayote. Thesis, University of California, Berkeley, United States. 149 pp. |6| Newstrom, L.E., 1989. Reproductive biology and evolution of the cultivated chayote (Sechium edule, Cucurbitaceae). In: Bock, G.H. & Linhart, Y.B. (Editors): The evolutionary ecology of plants. Westview Press, Boulder, San Francisco/London, United States/United Kingdom. pp. 491–509. |7| Whitaker, T.W. & Davis, G.N., 1962. Cucurbits: botany, cultivation and utilization. Leonard Hill, London, United Kingdom. 250 pp.

J.M.M. Engels & C. Jeffrey

Solanum L.

Sp. pl.: 184 (1753); Gen. pl.: 85 (1754).
SOLANACEAE
$x = 12$; $2n = 24$ (*S. ferox, S. macrocarpon, S. violaceum*)

Major species and synonyms

- *Solanum americanum* Miller – see separate article.
- *Solanum ferox* L., Sp. pl. ed. 2: 267 (1762), synonyms: *S. indicum* L. (1753), non auct., nomen ambiguum rejiciendum; *S. lasiocarpum* Dunal (1813); *S. stramonifolium* auct., non Jacq.
- *Solanum macrocarpon* L., Mant. pl. 2: 205 (1771), synonym: *S. dasyphyllum* Thonn. ex Schum. (1827).
- *Solanum melongena* L. – see separate article.
- *Solanum torvum* Swartz – see separate article.
- *Solanum violaceum* Ortega, Nov. pl. descr. dec.: 56 (1798), synonyms: *S. indicum* auct., non L.; *S. sodomeum* L. (1753), nomen ambiguum rejiciendum.

Vernacular names

- *S. ferox*. Brunei: tarong pasai. Indonesia: terong asam, cung bulu (South Sumatra), terong perat (Madura). Malaysia: terong iban, terong asam, terong dayak. Papua New Guinea: su, su-lamas (Pala, New Ireland), kova-sakau (Lamekot, New Ireland). Philippines: tabanburo (Tagalog), balbalusangi (Ilocano), tagatum (Bisaya). Burma: sinkade, tarabi. Laos: khüa khôn, khüa puux. Thailand: ma-uk (general), mapu (northern), yangkhuidi (Karen). Vietnam: c[af] bung.
- *S. macrocarpon*. African eggplant, gboma eggplant (En). Aubergine gboma (Fr). Indonesia: terong engkol, terong kelapa, terong gayung (Sundanese). Malaysia: terong santan, terong rapoh.
- *S. violaceum*. Malaysia: terong pipit. Philippines: talong-na-puti, talong-pipit (Tagalog). Laos: kh'èèngz khôm. Thailand: mawaeng, mawaengton (central), ma-khwaeng-dam (northern). Vietnam: c[af] d[aj]i hoa t[is]m, c[af] hoang.

Origin and geographic distribution The genus *Solanum* comprises about 1500 species, chiefly occurring in tropical and subtropical Central and South America with secondary centres of speciation in Australia and Africa. About 25 species occur in South-East Asia.
The origin of *S. ferox* is unknown. It is distributed from India to New Guinea, including all South-East Asian countries, and it occurs wild and cultivated. It is closely related to the South American *S. candidum* Lindley, but has never been reported from South America.
S. macrocarpon originates from the wetter parts of tropical and subtropical Africa where wild and cultivated forms occur. The cultivated form has been introduced into South-East Asia (Indonesia, Malaysia) and also into Central and South America.
The origin of *S. violaceum* is unknown. It is distributed wild and cultivated from India to and throughout South-East Asia.

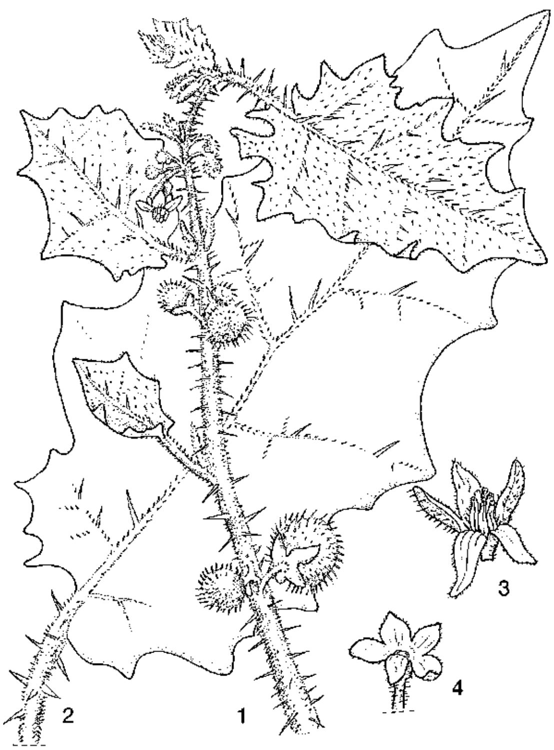
Uses The mature, acidic fruits of *S. ferox* are used as a sour relish in India, Malaysia and Thailand. They are also used to prepare curries and in Thailand it is an ingredient of the well-known sauce 'nam prek'. In Indonesia the fruits are eaten raw or cooked with rice. In traditional medicine the seeds are used to treat toothache by rolling them in a banana leaf, burning them as a cigar and inhaling the smoke. The roots are used to cure wounds, severe bruises, itch, syphilis and to relieve violent pains all over the body.
S. macrocarpon is used as a fruit and leaf vegetable. The young mature fruits are usually cooked and used in curry and soup. The leaves can be eaten raw, cooked or steamed. In South-East Asia its use is limited; in Africa it is an important vegetable.
S. violaceum is used as a fruit vegetable: immature and mature fruits are eaten raw, cooked or used for seasoning food. In traditional medicine the root is much used as a remedy in bronchitis and asthma. The seeds are used to relieve toothache.

Production and international trade In South-East Asia the three species considered here are home-garden crops or the fruits are collected from the wild (*S. ferox, S. violaceum*). No statistics are available. On local vegetable markets in Indonesia, Malaysia and Thailand the useful products are sometimes offered for sale. The economic importance of *S. macrocarpon* is largest in tropical Africa.

Properties Per 100 g edible portion, mature fruits of *S. macrocarpon* contain: water 89 g, protein 1.4 g, fat 1 g, carbohydrates 8 g, fibre 1.5 g, Ca 13 mg. The energy value is 168 kJ/100 g. Leaves of *S. macrocarpon* contain per 100 g edible portion: water 86 g, protein 4.6 g, fat 1 g, carbohydrates 6 g, fibre 1.6 g, Ca 391 mg. The energy value is 252 kJ/100 g. No information on the nutritive value of *S. ferox* and *S. violaceum* is available. Most wild fruits contain solanine, a not very poisonous alkaloid, acting like a saponin on the blood. The 1000-seed weight of *S. ferox* is about 2 g, of *S.*

macrocarpon 4–5 g and of *S. violaceum* about 1 g.

Description Annual or perennial herbs, erect or climbing, shrubs or rarely small trees. Plants unarmed or spiny, usually pubescent with simple, branched, glandular or stellate hairs. Leaves variable, usually alternate, exstipulate, petiolate, simple and entire, or lobed, pinnatisect or imparipinnate. Inflorescence a terminal, usually apparently lateral (by the growth of an axillary bud), often extra-axillary cyme, appearing racemose, subumbellate or paniculate, rarely reduced to a single flower. Flowers usually hermaphrodite; calyx campanulate, rotate or cupular, mostly 5-lobed; corolla stellate, rotate or campanulate, mostly 5-lobed; stamens usually 5, inserted on the corolla throat; anthers often connivent, forming a cone around the style, often dehiscing by terminal pores or slits; ovary superior, locules usually 2 with many ovules; style simple; stigma small, capitate or bifid. Fruit a berry, usually globose, with persistent and sometimes enlarged calyx. Seeds few to many, orbicular or subreniform, compressed, often minutely pitted or reticulate. Germination epigeal, first true leaves usually entire.



Solanum ferox L. – 1, flowering and fruiting shoot; 2, outline of lower leaf; 3, flower; 4, calyx.

– *S. ferox*. Herb or small shrub, up to 1(–2) m tall, densely stellately pubescent, armed with straight sharp prickles or unarmed. Leaves broadly ovate, 5–40 cm × 3–40 cm, markedly discolorous, shallowly pinnatilobed; petiole 5–16 cm long. Inflorescence up to 10-flowered; pedicel up to 2 cm long, armed or unarmed with prickles; calyx broadly campanulate, enveloping the fruit partly or completely, armed or unarmed with prickles; corolla stellate, white or purple. Fruit globose, 1.5–3 cm in diameter, yellow, densely pubescent with long white stellate hairs, glabrescent. Seed 2–2.5 mm long, pale yellow.

– *S. macrocarpon*. Perennial, glabrous, unarmed herb, up to 1.5 m tall with blackish violet stem, woody at the base. Leaves oblong-lanceolate, 10–30 cm × 4–15 cm, more or less deeply pinnatilobed or with undulate margins, discolorous; petiole 1–3 cm long, with narrow tapering wings. Inflorescence 2–7-flowered, lower flowers hermaphrodite, upper ones male; calyx campanulate, lobes much enlarged in fruit; corolla widely campanulate, light lilac with violet veins, up to 5 cm in diameter. Fruit depressed globose, 5–6 cm × 7–8 cm, orange-yellow, on a robust fruit stalk up to 3 cm long.

– *S. violaceum*. Slender armed to almost unarmed shrub, 1–1.5 m tall, densely grey tomentose, prickles variable in quantity, slightly curved. Leaves very variable, broadly ovate in outline, 3–15 cm × 2–12 cm, from sinuate to deeply pinnately 2–3-lobed; petiole 1–6 cm long. Inflorescence opposite a leaf, up to 12-flowered; calyx campanulate; corolla stellate, 2(–3) cm in diameter, pale to dark blue-purple. Fruit globose, about 1 cm in diameter, orange.

Growth and development Seed of *S. macrocarpon* germinates within 1–2 weeks of sowing, seed of *S. ferox* and *S. violaceum* takes longer. Flowering usually begins 3–4 months after sowing. Bees are the most effective natural pollinators; they vibrate or 'buzz' the anthers to release their pollen. High temperature and humidity in the morning tend to hasten the opening of the flowers and the dehiscence of the anthers. The stigma is receptive from just before flower opening until 2–3 days after opening. Fruits develop from anthesis to maturity in 2–3 months, but picking of green fruits for vegetable use may start 2–4 weeks after anthesis. The number of fruits developing per inflorescence varies from 1–2 in *S. ferox* and *S. macrocarpon* to 2–8 in *S. violaceum*. The plants usually remain productive for about one year, and even longer in *S. violaceum*.

Other botanical information Taxonomically, *S. ferox* is a problematic species. Linnaeus described it as a species from 'Malabaria' (India), with spiny stem, leaves, peduncles, and calyxes, and with a hairy fruit completely enclosed by the calyx. Later authors, whose view is followed here, considered *S. ferox* as a very variable complex species, comprising spiny and spineless forms and forms in which the fruit is completely or only partly enclosed by the calyx. The view that *S. ferox* should be restricted to specimens with hairy fruits, completely enclosed by a spiny calyx, and that other specimens of the complex are derived from the neotropical *S. candidum* Lindley, after an accidental introduction in the 16th Century, and developed into *S. lasiocarpum* Dunal, now distributed throughout South and South-East Asia, seems too artificial. Moreover, the interpretation of *S. lasiocarpum* as having a calyx and pedicel that are not spiny, is not in accordance with the protologue of Dunal.

Linnaeus' concept of his *S. indicum* L. appears to have been *S. ferox*. The name *S. indicum* L. has been rejected as a correct name because it causes confusion; more recent authors have often used the name *S. indicum* L. for plants now named correctly *S. violaceum*. *S. stramonifolium* Jacq. has also been used as the correct name for *S. ferox*. *S. stramonifolium*, however, is a different species, occurring in South America.

Wild and cultivated forms exist within *S. ferox*, both with edible fruits. The cultivated forms can best be classified in cv. groups and cultivars. A tentative classification is proposed here:

- cv. group Cung Bulu (syn. *S. ferox* L. var. *ferox*): in Indonesia; plants spiny; fruits hairy, 2–2.5 cm in diameter, completely enveloped by the spiny calyx.
- cv. group Domesticum (syn. *S. lasiocarpum* Dunal var. *domesticum* Heiser): in Thailand; plants unarmed, fruits hairy, over 3 cm in diameter, only at the base enveloped by a non spiny calyx.
- cv. group Involucratum (syn. *S. involucratum* Blume, *S. ferox* var. *involucratum* (Blume) Miquel): in Indonesia; robust spiny plants with purplish leaves; fruits hairy, 2–2.5 cm in diameter, completely enveloped by the spiny calyx.
- cv. group Sinkade (syn. *S. ferox* L. var. *ferox*): in Burma; plants spiny, fruits hairy, 2.5 cm in diameter, only at the base enveloped by a spiny calyx.
- cv. group Trongum (syn. *S. trongum* Poiret, *S. ferox* L. var. *trongum* (Poiret) Kurz): in Burma; plants spiny, fruits hairy, more than 2.5 cm in diameter, glabrescent at maturity, only at the base enveloped by a spiny calyx.

In Papua New Guinea armed (*S. ferox* L. var. *ferox*) and unarmed (*S. ferox* L. var. *repandum* (Forster) Bitter) forms exist, both with spiny or non spiny calyx that envelops the fruit only at the base, but they have not been reported as being cultivated.

For the cultivated forms of *S. macrocarpon* the cv. group name Macrocarpon (syn. *S. macrocarpon* L. var. *calvum* Bitter, *S. macrocarpon* L. ssp. *macrocarpon*) has been proposed. The cultivated forms are believed to have been derived from the wild form, named *S. dasyphyllum* or *S. macrocarpon* L. ssp. *dasyphyllum* (Thonn. ex Schum.) Jaeger.

What was formerly collectively called *S. indicum* by many authors is now divided into *S. anguivi* Lamk for Africa and *S. violaceum* Ortega for Asia. *S. anguivi* is considered to be the possible ancestor of *S. aethiopicum* L., the scarlet eggplant, which is a popular vegetable in Africa but hardly known in South-East Asia. *S. violaceum* is not closely related to *S. anguivi*; they differ in many aspects and they are not crossable.

Ecology *S. ferox* occurs wild in the Asian tropics in forest openings, on disturbed sites and in secondary thickets, often in shady sites, up to 1500 m altitude.

S. macrocarpon is sporadically cultivated in Indonesia and Malaysia up to 600 m altitude. It grows on a variety of soils, provided they are fertile. For optimum growth it needs full sun and plenty of water.

S. violaceum occurs wild in the Asian tropics as a weed of roadsides, waste places and abandoned fields from sea-level up to 2100 m altitude.

Propagation and planting Propagation is by seed or by shoot cuttings treated with a growth hormone to stimulate rooting. Before sowing, the seeds may be soaked overnight in water to promote even germination. Seeds are sown 0.5–1 cm deep in pots or seed-beds. Preferred growing conditions are temperatures of 25–32°C, a relative humidity of more than 80% and 50–75% shade. Seedlings with two leaves (2–3 weeks old) are transplanted into small polythene bags and kept under shade until they reach 15–20 cm height. After hardening for a few days the plants can be planted in the field.

Husbandry Usually a few plants are planted among other crops in the home garden. *S. macrocarpon* is also grown in larger quantities in the field, especially in Africa and India, allowing 1 m^2

space for each plant. Nitrogenous fertilizer is applied at regular intervals up to the flowering stage, for optimum growth.

Diseases and pests *S. macrocarpon* is susceptible to bacterial wilt (*Pseudomonas solanacearum*), root knot nematode (*Meloidogyne arenaria*), wilt (*Verticillium dahliae*) and phomopsis blight (*Phomopsis vexans*). The shoot and fruit borer *Leucinodes orbonalis* can cause serious damage. *S. violaceum* has been found susceptible to the root knot nematode *Meloidogyne arenaria*.

Harvesting For vegetable use the fruits are harvested at the immature to mature stage, starting 2–4 weeks after anthesis. For seed production fruits are harvested when they are fully ripe, 2–3 months after anthesis. Young leaves of *S. macrocarpon* are also picked for vegetable use.

Yield Per plant per season, *S. ferox* produces about 15 harvestable fruits, *S. macrocarpon* 3–8, and *S. violaceum* more than 30 fruits. The quality of the fruits usually declines after the first growing season.

Handling after harvest After harvesting the fruits are usually immediately consumed. They can be kept for 1–2 days under ambient conditions, and for about 1 week if stored at 10°C.

Genetic resources Germplasm collections of solanaceous crops are maintained in the United Kingdom (University of Birmingham), France (INRA, Montfavet), India (NBPGR, New Delhi) and the Netherlands (CPRO-DLO, Wageningen).

Breeding Some breeding programmes have been conducted on *S. macrocarpon*, especially in Africa, to produce cultivars resistant to diseases and pests and tolerant of drought, and to produce cultivars with a high yield of less bitter fruits.
Resistance to some diseases and pests present in *S. macrocarpon* and *S. violaceum* is interesting for breeding programmes of the economically more important solanaceous crops such as eggplant (*S. melongena* L.). In *S. macrocarpon*, resistance to black root rot (*Thielaviopsis basicola*), white fly (*Trialeurodes vaporariorum*) and red spider mite (*Tetranychus urticae*) has been found; in *S. violaceum*, resistance to phomopsis blight (*Phomopsis vexans*) and bacterial wilt (*Pseudomonas solanacearum*) has been observed.

Prospects *S. ferox* and *S. violaceum* will remain commercially minor vegetables in South-East Asia, unless their medicinal properties become more significant. Their importance for breeding programmes of other solanaceous crops is evident.
S. macrocarpon may have a brighter future as a commercial crop in South-East Asia, provided yields and cultural practices are improved to make the crop more popular.

Literature |1| Backer, C.A. & Bakhuizen van den Brink Jr, R.C., 1965. Flora of Java. Vol. 2. Wolters-Noordhoff, Groningen, the Netherlands, pp. 470–475. |2| Bitter, G., 1917. Die papuasischen Arten von Solanum [The Solanum species of Papuasia]. Botanische Jahrbücher 55: 59–113. |3| D'Arcy, W.G. (Editor), 1986. Solanaceae, biology and systematics. Columbia University Press, New York, United States. pp. 91–96, 412–415, 433–456. |4| Daunay, M.-C., Lester, R.N. & Laterrot, H. (in press). The use of wild species for the genetic improvement of brinjal eggplant (Solanum melongena) and tomato (Lycopersicon esculentum). In: Hawkes, J.G., Lester, R.N., Nee, M. & Estrada, N. (Editors): Solanaceae: taxonomy, chemistry, evolution. Royal Botanic Gardens, Kew, United Kingdom. |5| Hawkes, J.G., Lester, R.N. & Skelding, A.D. (Editors), 1979. The biology and taxonomy of the Solanaceae. Academic Press, Linnean Society of London, Linnean Society Symposium Series Number 7. 738 pp. |6| Hepper, F.N., 1978. Typification and name changes of some Old World Solanum species. Botanical Journal of the Linnean Society 76: 287–292. |7| Stevels, J.M.C., 1990. Légumes traditionnels du Cameroun, une étude agro-botanique [Traditional vegetables of Cameroun, an agro-botanic study]. Thesis. Wageningen Agricultural University Papers 90–1, Wageningen, the Netherlands. pp. 213–220. |8| Symon, D.E., 1981. A revision of the genus Solanum in Australia. Journal of the Adelaide Botanic Gardens 4: 1–367. |9| Whalen, M.D., Costich, D.E. & Heiser, C.B., 1981. Taxonomy of Solanum section Lasiocarpa. Gentes Herbarum 12(2): 41–129.

Sayed Mohd Zain Hasan & P.C.M. Jansen

Solanum americanum Miller

Gard. dict. ed. 8: Solanum No 5 (1768).
SOLANACEAE
$2n = 24$

Synonyms *Solanum nodiflorum* Jacq. (1789), *S. nigrum* auct. non L. (pro parte).

Vernacular names Glossy nightshade (En). Herbe à calalou (Fr). Indonesia: leunca (Sundanese), ranti (Javanese), kampai. Malaysia: ranti, terong meranti, terong perat. Papua New Guinea: karakap. Philippines: anti (Tagalog), bolagtab (Bisaya), kuti (Bicol). Laos: kh'èèngz namz. Thailand: mawaeng-nok (southern), ya-tomtok (northern). Vietnam: lu lu d[uwj]c, th[uf] l[uf] d[uwj]c.

Origin and geographic distribution *S. americanum* most probably originates from South America. It is now found throughout tropical and warm temperate regions, wild as a weed of cultivation and also cultivated. The *S. nigrum* complex in South-East Asia to which *S. americanum* belongs has not yet been studied, so the botanical names presented here are still tentative.

Uses The tender shoots, young leaves and unripe green fruits are eaten as a vegetable, raw, cooked or steamed (for 5–10 minutes), alone or in combination with other vegetables. Children dislike this vegetable because of its slightly bitter taste. The ripe fruits are also edible. In the Philippines they are used in pies, jams and other sweets. In traditional medicine a decoction of the leaves is used in a lotion for yaws and to alleviate neuralgic pains. The fruits have laxative and diuretic properties and the juice is applied against dropsy and to cure eye diseases of chickens. In West Java the berries are recommended as an aphrodisiac.

Production and international trade *S. americanum* is used as a green vegetable throughout South-East Asia and the green fruits can be bought in the local markets. It is common in the vegetable assortment of large supermarkets. Shoots and leaves are traded more rarely. No production figures are available, but being a common crop of home gardens and a common weed of cultivation, its importance is considerable.

Properties The edible portions of green fruits and young leaves are 95% and 70% respectively. Per 100 g edible portion the green fruits contain approximately: water 90 g, protein 1.9 g, fat 0.1 g, carbohydrates 7.4 g, Ca 274 mg, Fe 4.0 mg, carotene 0.5 mg, vitamin B_1 0.10 mg, vitamin C 17 mg. The energy value is 140 kJ/100 g.
The nutritional value of the leaves is good; it is comparable to that of *Amaranthus* leaves but with lower vitamin A and C contents. Per 100 g edible portion young leaves contain: water 85 g, protein 4.7 g, fat 0.5 g, carbohydrates 8.1 g, Ca 210 mg, Fe 6.1 mg, carotene 1.9 mg, vitamin B_1 0.14 mg, vitamin C 40 mg. The energy value is 190 kJ/100 g.
The seeds are light: 1000 seeds weigh approximately 1.5 g.

Description Erect and spreading annual or short-lived perennial herb, up to 1.5 m tall, unarmed, dark green or flushed with purple, glabrous or sparsely hairy with curved simple hairs. Stem terete, angular or narrowly winged, sometimes warty. Leaves arranged spirally to almost opposite, variable in size; petiole 1–4(–9) cm long, narrowly winged; leaf-blade ovate to ovate-lanceolate, (1–)6(–16) cm × (1–)3(–12) cm, entire or sinuately lobed, base truncate to cuneate and decurrent along the petiole, apex acuminate. Inflorescence an umbellate cyme with (2–)4–8(–20) flowers, mostly supra-axillary; peduncle slender, up to 2.5(–5) cm long; pedicel 3–8(–20) mm long, nodding; flowers bisexual, nodding; calyx campanulate, 1–3 mm long, 5-lobed, reflexed in fruit; corolla deeply 5-stellate, 8–9 mm in diameter, with yellow-green star, lobes oblong, 1.5 mm wide, reflexed, white or purplish; stamens 5, inserted on corolla throat; filaments 1–2 mm long, often hairy on inner side; anthers 1.5–2 mm long, yellow, opening by terminal pores; ovary globular, 1 mm in diameter; style 2.5–4 mm long, spreading hairy in lower half; stigma capitate, at about the level of the anther tips, pale green. Fruit a globular berry, 0.5–1 cm in diameter, from green turning glossy bluish-black or purplish-black at maturity, readily shed when ripe; flesh with 0–4(–8) sclerotic granules and 40–100 seeds. Seed discoid, 1–1.5 mm long, creamy.

Solanum americanum Miller – flowering and fruiting shoot.

Growth and development The germination of fresh glossy nightshade seeds is about 100% within 6 days. Flowering starts about 8 weeks after sowing (or 5 weeks after transplanting) and the number of flowers increases during the next 6 weeks. Young fruits appear about 10 days after anthesis and are harvestable 8 days later. Stem and roots grow until the age of 4–5 months; from about 2 months after sowing the stem gradually becomes more woody. At the age of about 4 months the plants shed many leaves; new leaves are formed, but they remain much smaller. Although plants can survive for more than one season, vegetable production (young fruits, leaves) is seriously reduced in old plants. The economic lifetime is about 5–6 months from sowing.

Other botanical information *S. americanum* is part of the *S. nigrum* complex, more formally *Solanum* L. section *Solanum*, also called section *Maurella* (Dun.) Dumort. or section *Morella* (Dun.) Bitter, which comprises about 30 species, mainly occurring in South America. The *S. nigrum* complex has not yet been unravelled. Some work has been done for South America, North America, Europe, India and Australia, but not so far for South-East Asia. The plants of the complex occurring in South-East Asia have been described as *S. nigrum* L. (s.l.) and as *S. nodiflorum* Jacq., which is considered synonymous with the older name *S. americanum*.

The '*nigrum*' complex in India is considered as consisting of three species: *S. americanum* Miller ($2n = 2x = 24$; inflorescence umbellate; fruit shiny purplish-black with reflexed sepals); *S. nigrum* L. ($2n = 6x = 72$; inflorescence racemiform; fruit dull purplish-black with sepals adhering to the fruit); and *S. villosum* Miller ($2n = 4x = 48$; fruits elliptical, very distinctive orange, orange-brown or reddish-orange). It is possible that the complex in South-East Asia contains the same elements; they do occur in Australia.

Until the situation has been cleared up worldwide, the name *S. americanum* is applied here to edible plants of the South-East Asian '*nigrum*' complex.

Two forms occur in West Java (Indonesia): forms with small bluish-black fruits, about 0.5 cm in diameter, only the leaves of which are used as vegetable (called 'leunca manuk' or 'leunca ayam') and forms with larger shiny purplish-black fruits, about 1 cm in diameter, whose green fruits and leaves are used as vegetable (called 'leunca biasa' or 'leunca badak'). Only the forms with larger fruits are cultivated.

Ecology *S. americanum* can be found in a wide range of environments, usually associated with some degree of man-made disturbance such as waste places, orchards, gardens, light grazings and alongside footpaths. In the tropics it is found especially in the montane zone up to 3000 m altitude, but also at sea-level.

Propagation and planting *S. americanum* is propagated by seed. It is usually sown in seed-beds or in pots and planted in the field when the plants are about 8 cm tall, five weeks after sowing. It is normally planted in home gardens but also in fields. When water supply is assured, *S. americanum* can be grown year-round in the tropics.

The planting distance depends on the harvested product: when leaves are primarily desired a close planting distance of up to 25 cm × 25 cm is preferred; when fruits are primarily wanted, distances are wider, e.g. 50 cm × 50 cm; for a combination of leaves and fruits intermediate distances are recommended. In practice, however, *S. americanum* is usually grown in home gardens, mixed with other crops.

Husbandry Cultural practices for glossy nightshade are similar to those recommended for capsicum pepper. Manure is usually applied, at 100–500 g per plant; sometimes some NPK fertilizer is given too. Weeding is done once every 2–3 weeks as long as it is necessary and watering twice a week, depending on natural rainfall. If good fruit yields are required as well as edible leaves, it is recommended to trim regularly so that 4–5 branches remain. Although the plants can be grown in full sun, experiments in Indonesia also showed beneficial effects of shade. In general, the more shade, the more stem and leaves and the less fruits are produced. Up to 60% shade, leaf harvests were not significantly lower than without shade, and leaves were thinner, larger and better in taste.

Diseases and pests *S. americanum* has no serious diseases and pests.

In Indonesia only moderate losses have been reported from diseases such as bacterial wilt (*Pseudomonas solanacearum*), fusarium wilt (*Fusarium oxysporum* f. *lycopersici*), and root knot nematodes. Sometimes aphids and beetles (*Epilachna* spp.) may attack the plants. These pests can be controlled by hand.

Harvesting For home consumption the plants are harvested when the product is wanted, starting about 2 months after sowing. For leafy vegetable, young shoots 5–6 cm long are harvested, about once per 1–2 weeks. Young fruits are har-

vested per bunch of 7–8 fruits, once per 3–10 days, most frequently in the wet season.
Harvesting usually continues for 3–5 months, depending on the condition of the plants and the desired quality of the product.

Yield Only figures from one experiment in Indonesia are available. Plants were harvested until 4 months after planting in the field; mean fruit yield was 30 kg per 10 m^2 (30 t/ha) when leaves were not harvested, and 16 kg per 10 m^2 (16 t/ha) when also 0.8 kg edible leaves per 10 m^2 (0.8 t/ha) were harvested. Yields were expected to be higher at closer spacings (these yields were obtained with plants spaced 50 cm × 70 cm).

Handling after harvest Edible leaves should be consumed or prepared as soon as possible, keeping them wet to prevent wilting. Young fruits should also be prepared as soon as possible after harvest although they probably can be kept as long as green tomatoes.

Genetic resources and breeding No specific germplasm collections of *S. americanum* exist. It may be assumed that some material is available at institutes keeping germplasm collections of other solanaceous crops.
If interest is shown in developing *S. americanum* as a crop and in starting crop improvement programmes, the first step must be to organize a worldwide germplasm collection, as glossy nightshade is very variable.

Prospects *S. americanum* is an interesting species for home and market gardening, tolerating shade, easy to cultivate, without serious diseases and pests, producing nutritive fruits and shoots. It deserves more research attention.

Literature |**1**| Edmonds, J.M., 1972. A synopsis of the taxonomy of Solanum sect. Solanum (Maurella) in South America. Kew Bulletin 27: 95–114. |**2**| Edmonds, J.M., 1977. Taxonomic studies on Solanum section Solanum (Maurella). Botanical Journal of the Linnean Society 75: 141–178. |**3**| Edmonds, J.M., 1979. Biosystematics of Solanum L. section Solanum (Maurella). In: Hawkes, J.G., Lester, R.N. & Skelding, A.D. (Editors): The biology and taxonomy of the Solanaceae. Academic Press, Linnean Society of London, Linnean Society Symposium Series Number 7. pp. 529–548. |**4**| Omta, S.W.F. & Fortuin, F.T.J.M., 1978. The cultivation of Solanum nigrum L. as a leaf and fruit vegetable in the home gardens of West Java. Mimeographed research report. Institute of Ecology, Pajajaran University, Bandung, Indonesia & Department of Plantphysiology, State University, Groningen, the Netherlands. 70 pp. |**5**| Schilling, E.E. & Andersen, R.N., 1990. The black nightshades (Solanum section Solanum) of the Indian subcontinent. Botanical Journal of the Linnean Society 102: 253–259. |**6**| Symon, D.E., 1981. A revision of the genus Solanum in Australia. Journal of the Adelaide Botanic Gardens 4: 1–367, especially pp. 37–56.

J.S. Siemonsma & P.C.M. Jansen

Solanum melongena L.

Sp. pl.: 186 (1753).
SOLANACEAE
$2n = 24$

Synonyms *Solanum coagulans* Forsskal (1775), *S. cumingii* Dunal (1852), *S. pressum* Dunal (1852), *S. undatum* Poiret sensu Ochse.

Vernacular names Eggplant, aubergine, melongene, brinjal (En). Aubergine, melongène, bringelle (Fr.). Indonesia: terong, encung, tiung (Sumatra). Malaysia: terong. Philippines: talong (Tagalog), tarong (Ilocano), bringhinas (Bisaya). Burma: kayan. Cambodia: trâb vèèng, trâb put lonhoong. Laos: khüa poom, khüa hlèèz, khüa ham maaz. Thailand: makhua-yao, makhua-chan, makhua-khao. Vietnam: c[af] t[is]m, c[af] b[as]t.

Origin and geographic distribution The eggplant most probably originated in the Indo-Burmese region, where it is an ancient crop and occurs with great variability; secondary centres of diversity are China and possibly Africa. Now it has spread throughout the tropics, subtropics and the warm temperate regions; in temperate climates it is also grown in greenhouses.

Uses The young and almost mature fruits are used as a vegetable. They may be roasted, fried, stuffed, cooked as curry, pickled or prepared in some other manner. In Indonesia and Malaysia young fruits are also eaten raw. The eggplant is widely used in traditional medicine. In Malaysia the ashes of the fruit are prescribed for use in a dry hot poultice on haemorrhoids and the pounded root is applied inside the nostrils against ulceration. In India the eggplant is used in medicines to cure diabetes, asthma, cholera, bronchitis and dysuria. The fresh or dry leaf and fruit are said to reduce blood cholesterol level. In New Guinea, the juice from the roots is used to cure otitis and toothache.

Production and international trade In 1987 total world production of eggplant fruits was estimated at 5.5 million t, cultivated on 430 000 ha. For South-East Asia some figures are: Indonesia

(1988) 168 000 t from 32 000 ha, the Philippines (1987) 90 000 t from 15 000 ha, Thailand (1987) 58 000 t from 11 000 ha. It is a common market vegetable in tropical countries. Most of the production from home gardens or in mixed intercropping with field crops is for home use. The eggplant is most important in China, India, South-East Asia, northern Africa and the Mediterranean area.

Properties Per 100 g edible portion, the fruits contain approximately: water 92 g, protein 1.6 g, fat 0.2 g, carbohydrates 4.0 g, fibre 1.0 g, ash 0.6 g, Ca 22 mg, Fe 0.9 mg, vitamin B_1 0.08 mg, vitamin B_2 0.07 mg, niacin 0.7 g, vitamin C 6.0 mg. The energy value is about 100 kJ/100 g. About 4% of the harvested product is waste. The 1000-seed weight is approximately 4 g.

Description An erect, branching, very polymorphous, perennial herb, up to 1.5 m tall, grown as an annual, with strong, deeply penetrating taproot. All parts covered with a grey tomentum, sometimes plants are somewhat spiny, older plants may become woody. Leaves alternate, simple; petiole up to 10 cm long; leaf-blade ovate to ovate-oblong, 3–25 cm × 5–15 cm, densely stellate hairy, base rounded or cordate, often unequal, margin sinuately lobed, apex acute or obtuse. Flowers solitary or in 2–5-flowered cymes, hermaphrodite or male (andromonoecy), opposite the leaves, 3–5 cm in diameter; pedicel 1–3 cm long, in fruit up to 7 cm; calyx tubular-campanulate; about 2 cm long, 5–7-lobed, spiny, woolly, persistent and enlarging in fruit when it often splits; corolla gamopetalous, deeply 5–6-lobed and stellately spreading, purplish-violet, lobes hairy beneath; stamens 5–6, about 1 cm long, anthers opening by two terminal pores; ovary 2-locular, style simple, stigma capitate. Fruit a large pendent berry, ovoid, oblongoid, obovoid or subglobose to globose, up to 40 cm long and 20 cm in diameter but very variable, smooth, shiny, white, green, yellow, purple, black or mixed coloured. Seeds numerous, small, light-brown.

Solanum melongena L. – flowering and fruiting shoot.

Growth and development Germination of seed is epigeal and takes about 2 weeks. Young plants can be transplanted to the field about 4–6 weeks after sowing. Flowering starts 6–8 weeks after transplanting. Eggplants are normally self-pollinated, but 6–20% cross pollination by insects (bees) may occur. Fruits can be harvested starting about 5 weeks after flowering, depending on cultivar and desired maturity rate. Normally 8–14 fruits per plant will be produced, after which the economic lifetime of eggplant is over. If old plants are cut back they frequently resprout and bear in a second season, but accumulated disease problems often make this impossible or uneconomic.

Other botanical information *S. melongena* is very variable in fruit form and colour and the variation is continuous, which means that existing subclassifications into botanical varieties and subspecies have no practical value. More practical would be a classification into cultivar groups and cultivars. Worldwide, important cultivars are 'Black Beauty', 'Florida Market' and 'Long Purple'. In South-East Asia, local cultivars are more common than the high-yielding exotic cultivars since they are better adapted to local conditions. Selection and registration of local cultivars is still rare. In South-East Asia there are two distinct types of eggplant cultivars, which may be distinguished as cultivar groups:

- Cv. group Common Eggplant. Characterized by a robust habit, more or less pronounced purplish flowers, and persistent calices at the base of the big round to elongated oval fruits. The immature fruits are extremely variable in form, size and colour, showing variations between purple, green and white. A popular local type in Indonesia is 'Kopek', which has elongated fruits with an obtuse end. The fruits of common eggplant are normally used as a cooked vegetable but in Indonesia the light green long types are also consumed raw. This cv. group also includes the type of 'international' cultivars such as 'Long Purple'.

- Cv. group Bogor Eggplant. Characterized by a small spreading habit, small greyish leaves, and small greenish-white flowers. The fruits are round or flat-round, 4–10 cm in diameter, green near the calyx which partly envelops the fruit, and marbled white at the top. In Indonesia, the tender, crispy, slightly bitter-tasting fruits of cv. group Bogor Eggplant, also called 'Kelapa', are very popular for raw consumption. A popular cultivar with small fruits is 'Gelatik'.

Both cv. groups do not cross easily. A taxonomic study is needed to determine whether cv. group Bogor Eggplant deserves species ranking.

Ecology Optimum day temperatures for eggplant range between 25–35°C, night temperatures between 20–27°C. Eggplant is more susceptible to low temperatures than tomato and capsicum pepper and it does not tolerate frost. Eggplant is tolerant of drought and excessive rainfall, but in general fruit set and production decrease under adverse conditions. As far as is known it is daylength neutral. It does best in well-drained, sandy loam. The most satisfactory environmental conditions are normally found in lowland areas with relatively little temperature variation. When grown at altitudes above 800 m growth is retarded and yield reduced.

Propagation and planting Eggplant is normally propagated by seed. Propagation by rooting of healthy shoots is also possible. Soaking the seeds in water for 24 hours hastens germination. Seeds are sown in containers or seed-beds in a nursery. About 200 g seed is required for 20 000–30 000 plants/ha. With a good nursery method, it is possible to produce enough plants for one hectare with only 60 g of seed. This is especially important when expensive hybrid seed is used. The practice is to sow in a shaded seed-bed; the seedlings emerge after 8–10 days and are pricked out in small pots of banana leaf 2–3 weeks later; after 3 weeks these banana-leaf pots are transplanted to the field, on raised beds or ridges. For ridge planting 70–90 cm between rows and 50–60 cm between plants is commonly practised. Before planting, the field is manured with compost or farmyard manure or at planting a complete mineral fertilizer solution (NPK 1 : 1 : 1, 500 kg/ha) is applied. In Indonesia it is recommended to supply 0.5 kg of farmyard manure with 10 g of triple superphosphate, 5 g KCl and 5 g of urea per planting hole.

Husbandry Weed control should be shallow, to avoid damage to the roots. When plants are established the terminal growing point may be removed to encourage lateral branching. Tall-growing cultivars will also require support.

Supplementary irrigation is required during dry periods. Mulching with dried plant materials or with thin black polyethylene sheets reduces moisture loss and weed problems.

The need for additional fertilizer during growth depends on local conditions. Eggplants are heavy feeders and they benefit from additional fertilizer dressings of nitrogen (as urea or ammonium sulphate) and in some cases also potassium, about 4 and 6 weeks after transplanting.

Diseases and pests In general, cultivars of cv. group Common Eggplant are more susceptible to diseases and pests than cv. group Bogor Eggplant. The most destructive diseases and pests reported from South-East Asia are bacterial wilt, *Phomopsis* fruit rot and *Epilachna* beetles. Bacterial wilt (*Pseudomonas solanacearum*) occurs with bad drainage and is often combined with symptoms of root knot nematodes. It can easily be controlled by the use of resistant cultivars such as the Indonesian 'Kopek Ungu'. Phomopsis rot (*Phomopsis vexans*) causes rotting spot of stems, leaves and fruits. It is controlled by the use of healthy seed and by sanitation, removing all diseased plants or fruits from the field. Farmers spray with dithiocarbamates against this disease. Leaf beetles (*Epilachna sparsa*) are a very common and devastating pest of eggplant, controlled by spraying with insecticides. Other diseases and pests reported from South-East Asian countries are green stink bug (*Nezara viridula*), mites (*Tetranychus* spp.), aphids, root knot nematodes, anthracnose fruit rot (*Colletotrichum melongenae, Gloeosporium melongenae*), *Sclerotium* wilt, *Cercospora* leafspot, *Phytophthora* fruit rot and several virus diseases (tobacco rattle, cucumber mosaic, tomato ringspot).

Harvesting The first harvestable fruits appear 60–90 days after planting. Fruits are harvested when they are about two-thirds of their maximum size. Harvesting is done once or twice a week. For seed production, only fully mature fruits should be harvested from healthy and productive plants.

Yield A high yield is 25–50 t/ha. The yielding capacity of cv. group Bogor Eggplant is much lower than that of cv. group Common Eggplant. World average yield in 1987 was about 13 t/ha, but it was much lower in South-East Asia: 5.2 t/ha in Indonesia (1988), 6 t/ha in the Philippines (1987), 5.5 t/ha in Thailand (1987). In seed production, a seed yield of 100–200 kg/ha can be obtained, depending on cultivar and conditions.

Handling after harvest After grading on quality the fruits are packed in bags, crates or baskets. Eggplant fruits are more resistant to rough handling and transport than tomato or capsicum pepper. After a few days the quality will decline by crinkling and rotting. Cooling of fruits considerably prolongs their storage life. With cooling at 10–13°C and a high relative humidity, eggplant can be stored for 2–3 weeks.

Genetic resources Hundreds of landraces and cultivars of *S. melongena* have been collected in gene banks in the United States, Europe and India. Few collections of primitive or more advanced local cultivars have been reported. A working collection is present at the Lembang Horticultural Research Institute (LEHRI) in Indonesia. In all tropical countries traditional cultivars are being replaced by more advanced, high-yielding cultivars, enhancing genetic erosion. Collection of local cultivars is urgent, and material should be screened for disease and pest resistance.

Breeding Much breeding work (pure-line selection) has been carried out, mostly in the United States, but also in India, Thailand, the Philippines and Indonesia. Eggplant withstands inbreeding and shows some heterosis. Hybrid cultivars have been bred, applying male sterility, but these are not yet widely cultivated.
In the Philippines 'Bulacan' is a high-yielding cultivar containing very few seeds, and is resistant to bacterial wilt. 'College Long Purple' and 'Dingras Multiple Purple', also from the Philippines, are resistant to bacterial wilt as well, as is 'Kopek' from Java (Indonesia). Resistance breeding to wilt diseases and root knot nematodes should have first priority. Much can still be expected from traditional cultivars of eggplant and related species, e.g. *Solanum americanum* Miller, *S. incanum* L., *S. macrocarpon* L., *S. violaceum* Ortega, *S. aethiopicum* L., *S. sisymbriifolium* Lamk and *S. torvum* Swartz.

Prospects Eggplant is a relatively easy to cultivate and high-yielding vegetable with a reasonable nutritional value. It should be possible to breed into eggplant resistance for the most destructive diseases of the hot humid tropics, bacterial wilt and *Phomopsis* rot. In South-East Asia, the future of eggplant can be bright if the genetic richness of local cultivars is better exploited.

Literature |1| Choudhury, B., 1976. Eggplant. In: Simmonds, N.W. (Editor): Evolution of crop plants. Longman, London, United Kingdom. pp. 80–81. |2| Deanon Jr, J.R., 1967. Eggplant, tomato and pepper. In: Knott, J.E. & Deanon Jr, J.R. (Editors): Vegetable production in South-East Asia. University of the Philippines Press, Los Baños, the Philippines. pp. 97–137. |3| Grubben, G.J.H., 1977. Tropical vegetables and their genetic resources. Tindall, H.D. & Williams, J.T. (Editors). International Board for Plant Genetic Resources (IBPGR), Rome, Italy. pp. 34–37. |4| Khan, R., 1979. Solanum melongena and its ancestral forms. In: Hawkes, J.G., Lester, R.N. & Skelding, A.D. (Editors): The biology and taxonomy of the Solanaceae. Academic Press, Linnean Society of London, Linnean Society Symposium Series Number 7. pp. 629–636. |5| Martin, F.W. & Pollack, B.L., 1979. Vegetables for the hot humid tropics. Part 5. Eggplant, Solanum melongena. Science and Education Administration, United States Department of Agriculture, New Orleans, United States. 18 pp. |6| Som, M.G. & Maity, T.K., 1986. Brinjal. In: Bose, T.K. & Som, M.G. (Editors): Vegetable crops in India. Naya Prokash Press, Calcutta, India. pp. 293–342. |7| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 365–369.

H. Sutarno, S. Danimihardja & G.J.H. Grubben

Solanum torvum Swartz

Nov. gen. sp. pl. prodr.: 47 (1788).
SOLANACEAE
$2n = 24, 48$

Synonyms *Solanum ferrugineum* Jacq. (1798), *S. largiflorum* C. White (1917).

Vernacular names Devil's fig, plate brush (En). Indonesia: takokak, pokak (Javanese), terong pipit (Sumatra). Malaysia: terong pipit, terong rembang. Papua New Guinea: podopodo kai ra ta ba rau (New Britain, Kuanua). Philippines: takapasin (Tagalog), taogotan (Bisaya), balbalusa (Bontoc). Laos: kh'èèngz f'aaz, kh'èèngz saph'au. Thailand: makhua-phuang (general), makhwaeng (northern). Vietnam: c[af] d[aj]i hoa tr[aws]ng, c[af] hoang.

Origin and geographic distribution *S. torvum* originates from the Antilles, but is now a pantropical weed. Occasionally it is also cultivated, especially in South, South-East and East Asia.

Uses Young, immature fruits are eaten raw or cooked as vegetable or are used as an ingredient in curry sauce. In Indonesia *S. torvum* is considered one of the best vegetable side-dishes with rice.

In traditional medicine, various uses are reported: roots for poulticing cracks in the feet (Malaysia) or as an antitussive in China where they are believed to disperse extravasated blood and to relieve pain; seeds are smoked in Malaysia for curing toothache; in India extracts of the plant are used as antidote to snakebite and insect stings, and fruits are eaten to relieve stomach pain.

S. torvum is sometimes used as a rootstock for tomato (Brunei) to resist bacterial wilt, and for eggplant (Japan, Trinidad) and for *S. quitoense* Lamk (Colombia, Ecuador).

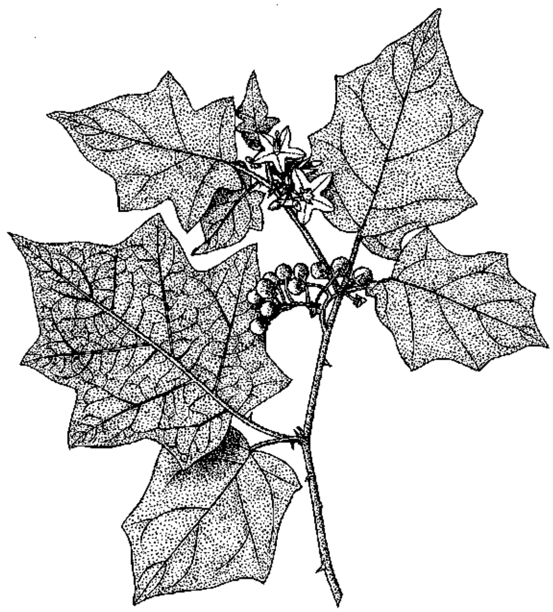
Production and international trade No statistics are available. Fruits are mainly gathered from wild plants or from plants cultivated in home gardens; they are consumed and marketed locally. It is common in the vegetable assortment of large supermarkets.

Properties Per 100 g edible portion, young fruits contain: water 89 g, protein 2 g, fat 0.1 g, carbohydrates 7.9 g, Ca 50 mg, P 30 mg, Fe 2 mg, vitamin A 750 IU, vitamin B_1 0.08 mg, vitamin C 80 mg. The energy value is 160 kJ/100 g.

The steroidal alkaloid solasodine, which is used in the manufacture of steroidal sex hormone for oral contraceptives, is present (0.84%) in the leaves and fruits.

In tropical pastures, *S. torvum* can be a troublesome weed. In Australia it is suspected of poisoning livestock; in Papua New Guinea it is suspected to be a causal agent of enzootic calcinosis in cattle.

Botany A spreading or scrambling slender shrub, up to 3 m tall, pubescent with stellate hairs. Prickles scattered on stem, branches and leaves, especially in younger growth, 3–7 mm long, slightly hooked. Leaves alternate, solitary or in pairs, variable; petiole 1.5–5 cm long; leaf-blade ovate, 7–20 cm × 4–18 cm, coarsely, sinuously 7-lobed; base equal or unequal, somewhat sagittate to auriculate; lobes triangular, 3–4 cm long, acute or obtuse. Inflorescence a compact, branched, 50–100-flowered corymb, at first terminal, later becoming lateral and markedly supra-axillary; peduncle 1–2 cm long; pedicel 0.5–1 cm long, slightly elongating and thickening in fruit; flowers hermaphrodite, upper ones may be male; calyx 5-lobed, 3–4 mm long, persistent; corolla stellate, 2.5 cm in diameter, white, lobes 5, lanceolate, 1 cm long; stamens 5, inserted on corolla throat, anthers attenuate, 6–7 mm long on very short filaments; ovary globose, pubescent, style 8–10 mm long. Fruit a globular berry, 1–1.5 cm in diameter, yellowish, glabrous, produced in clusters of few to 10. Seeds 300–400 per fruit, flat, 1.5–2 mm long, brownish.



Solanum torvum Swartz – flowering and fruiting shoot.

S. torvum flowers throughout the year, but relatively few flowers set fruit. Heavy rainfall also discourages fruit set. Plants are said to have an economic lifetime of 3–4 years. The large variability within the species has led to various classifications, but no strict lines can be drawn between the distinguished taxa. The correctness of the name *S. torvum* is still subject of discussion. Some authors consider *S. ficifolium* Ortega as the correct name for this taxon. No cultivar names have yet been employed for cultivated forms.

Ecology *S. torvum* is a common pantropical weed, common along roadsides and in waste places after soil disturbance, usually as individual plants. In cultivated fields it is not usually a troublesome weed. It prefers moist, but not too wet places, and occurs up to 1600 m altitude.

Agronomy *S. torvum* is easily propagated by seed, but can also be propagated by separating rooted shoots. In South-East Asia it is usually planted in home gardens, at distances about 1.5–2 m square. Instead of being cultivated it is often only spared if it grows naturally. *S. torvum* has no serious diseases or pests. In India a leaf-spot (*Alternaria solani*) and a shoot and fruit borer (*Leucinodes orbonalis*) have been reported. It is susceptible to nematodes (*Meloidogyne* spp.); in cultivation a rotation scheme can avoid problems. The fruits are harvested when still immature.

Genetic resources and breeding No substantial germplasm collections or breeding programmes for its own improvement exist as far as is known. Its importance for breeding is its resistance to *Verticillium* wilt; attempts are being made to incorporate this character in more important solanaceous crops. *S. torvum* is used as a rootstock for other crops.

Prospects *S. torvum* is considered a good vegetable, and deserves more research attention. Its major significance at present is as a rootstock and as a source of resistance against diseases and pests for economically more important solanaceous crops.

Literature |1| Backer, C.A. & Bakhuizen van den Brink Jr, R.C., 1965. Flora of Java. Vol. 2. Wolters-Noordhoff, Groningen, the Netherlands. p. 475. |2| Hepper, F.N., 1987. Solanaceae. In: Dassanayake, M.D. & Fosberg, F.R. (Editors): A revised handbook to the flora of Ceylon. Vol. 6. Amerind Publishing Company, New Delhi, India. pp. 376–378. |3| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 685–686. |4| Symon, D.E., 1981. A revision of the genus Solanum in Australia. Journal of the Adelaide Botanic Gardens 4: 115–116.

T. Boonkerd, B. Na Songkhla & W. Thephuttee

Sonchus L.

Sp. pl.: 793 (1753); Gen. pl. ed. 5: 347 (1754).
COMPOSITAE

$x = 7, 8, 9$; $2n = 18$ (*Sonchus asper, S. wightianus*); $2n = 32$ (*S. oleraceus*); $2n = 54$ (*S. malaianus*)

Major species and synonyms
- *Sonchus asper* (L.) Hill, Herb. Brit. 1: 47 (1769), synonym: *S. cuspidatus* Blume (1826).
- *Sonchus malaianus* Miquel, Fl. Ind. Bat. 2: 113 (1856), synonyms: *S. javanicus* Jungh. (1845), non Sprengel (1826), *S. oreophilus* Miquel (1856), *S. maritimus* L. var. *malaianus* (Miquel) Hochr. (1934).
- *Sonchus oleraceus* L., Sp. pl.: 794 (1753), synonym: *S. sundaicus* Blume (1826).
- *Sonchus wightianus* DC., Prodr. 7: 187 (1838), synonym: *S. arvensis* L. sensu mult. auct.

Vernacular names
- *S. asper*: Spiny sow thistle (En). Laitron épineux (Fr). Indonesia: delgiyu (Javanese), camawak (Sundanese). Thailand: phakkat-hom (central), phakkat-hangkai (southern).
- *S. malaianus*: Indonesia: kumindelan, blenggi.
- *S. oleraceus*: Common sow thistle (En). Laitron commun (Fr). Indonesia: tempuh wiyang, delgiyu (Javanese), camawak (Sundanese). Philippines: gagatang (Igorot). Vietnam: rau di[ees]p d[aj]i, nh[ux] c[us]c, rau c[us]c s[uwx]a.
- *S. wightianus*: Indonesia: tempuyung (Javanese), lempung (Sundanese), jombang. Philippines: lampaka (Ilocano), lunglung an manema (Ifugao), pisay a otan (Marinduque). Vietnam: nh[ux] c[us]c d[oof]ng.

Origin and geographic distribution The genus *Sonchus* is of Old World origin and is widely distributed. *S. asper* and *S. oleraceus* are cosmopolitan weeds, occurring from the Arctic zone to the tropics. *S. wightianus* is of Asian origin and distributed from Afghanistan through South Asia and Indo-China to Taiwan. In Malesia it occurs in the Philippines and Indonesia (Java). *S. malaianus* is endemic to the Indonesian islands of Sumatra and Java.

Uses *Sonchus* species have a long record of being used as leafy vegetables in many parts of the world. The leaves are consumed raw as a salad or cooked as a spinach. They are also a good animal feed. *S. asper* and *S. oleraceus* are applied worldwide in folk medicine as stomachic, aperitive and diuretic. *S. wightianus* is used in Indonesia to treat kidney stones and jaundice.

Production and international trade For vegetable use, *Sonchus* leaves are gathered mainly from the wild. However, *S. wightianus* is planted on a small scale in Java, mainly to produce tablets and tea bags for medicinal use. No statistics are available.

Properties There is no information on the nutritional value of *Sonchus* leaves. *S. wightianus* is reported to contain taraxasterol and inositol. The capacity of leaf extract to dissolve calcium from kidney stones is greatest in *S. wightianus* and less so in *S. oleraceus* and *S. asper*. The 1000-seed weight of *S. wightianus* has been reported to be 0.4 g.

Description Annual or perennial, erect herbs up to 3 m tall, containing a bitter milky juice, with a well-developed branched taproot or rarely a

Sonchus oleraceus L. – flowering and fruiting plant.

creeping rhizome. Stems hollow, cylindrical or slightly angular, glabrous or with glandular hairs near the top. Leaves in a rosette or cauline, alternate, usually auricled and clasping, usually divided and with denticulate margins. Inflorescence a head, usually numerous and arranged in terminal corymbs, each head with 40–500 bisexual flowers; peduncle 0.2–16 cm long, with 1–12 triangular bracts; involucral bracts numerous, imbricated in 3 rows; corolla ligulate, 1–3 cm long, yellow, with a 4–14 mm long linear ligule, 5-dentate at top; the relative lengths of the corolla tube and the ligule are important for the distinction of the species; anthers 5, forming a staminal tube; style with 2 branches. Fruit an achene, usually ellipsoid, 2–6.5 mm × 0.5–1.75 mm, laterally compressed, brown, with 1–4 main ribs on each side, with a 4–14 mm long caducous or persistent pappus.

- *S. asper*. Annual, polymorphic, branched herb, up to 120 cm tall. Leaves mostly cauline, variable in outline, 5–25 cm × 3–8 cm, entire to pinnatipartite; lobes more or less triangular, with spiny margins. Per head 80–300 flowers; involucral bracts ca. 40; corolla tube ca. 6 mm, ligule 4 mm long. Achene strongly compressed, 2–3 mm × 1 mm, with 3 ribs on each side and winged, ciliate margins; pappus ca. 3 times as long as the achene, caducous.
- *S. malaianus*. Perennial, branched herb, up to 180 cm tall. Cauline leaves, narrowly elliptical to rectangular, 8–28 cm × 0.5–3.5 cm, entire, subcoriaceous, margins entire or dentate. Per head 100–150 flowers; involucral bracts ca. 35; corolla tube 7–10 mm, ligule 7–8.5 mm long. Achene wrinkled, 4–4.5 mm × 1.2 mm, with 1 major and 4 minor ribs on each side; pappus ca. 11 mm long, subpersistent.
- *S. oleraceus*. Annual or biennial, branched herb, up to 140 cm tall. Cauline leaves, variable in outline, 8–35 cm × 4–17 cm, entire to pinnatipartite; lobes entire, dentate or spiny. Per head 80–230 flowers; involucral bracts ca. 30; corolla tube as long as the ligule, 6 mm. Achene rough, oblanceolate, 2.5–3.75 mm × 0.75–1 mm, with 2–4 main ribs on each side; pappus about two times as long as the achene, subpersistent.
- *S. wightianus*. Perennial, branched herb, up to 140 cm tall, always with a taproot, sometimes rhizomatic as well. Rosette and cauline leaves 5–30 cm × 1–6 cm, entire to pinnatipartite; lobes more or less triangular, with dentate to spiny margin; upper leaves short, lanceolate to narrowly triangular. Per head 180–300 flowers; involucral bracts ca. 40, densely glandular hairy; corolla tube 7–8 mm, ligule 5–6 mm long. Achene wrinkled, 3.5–4.25 mm × 1 mm, with 1 major and 4 minor ribs on each side; pappus ca. 8 mm long, subpersistent.

Other botanical information *S. asper* was originally described as a variety of *S. oleraceus*. Hybrids between these two taxa are sterile ($2n = 25$), so it seems better to consider them as different species. Forms of *S. asper* with the flowerheads arranged in umbels, the leaves stiff and very spiny and all in a rosette, and the achenes with pronounced and ciliate ridges, have been classified as ssp. *glaucescens* (Jordan) Ball.

S. malaianus is probably a hexaploid species with $x = 9$. Its entire and subcoriaceous leaves are very distinctive. It is more common in Java than Sumatra.

S. oleraceus has very variable leaves, probably due to its supposed amphidiploid origin (*S. asper* × *S. tenerrimus* L., $2n = 18 + 14 = 32$). The more or less equal length of the tube and the ligule of its corolla is very characteristic for this species (for *S. asper* that ratio is 2 : 3). The species has often been subdivided into different taxa, based on vegetative characters. Its variability is such, that two identical plants can rarely be found, so that any subdivision seems without practical value.

S. wightianus has often been considered as a synonym of *S. arvensis* L., the milk thistle of Europe and America, but it is a different species. *S. wightianus* always has a taproot (*S. arvensis* is purely rhizomatic) and its fruits are longer, narrower and less wrinkled than those of *S. arvensis*. *S. arvensis* does not occur in South-East Asia. Forms of *S. wightianus* with white-hairy heads without glandular hairs are classified as ssp. *wallichianus* (DC.) Boulos.

Ecology The wide distribution of *S. asper* and *S. oleraceus* is proof of their great ecological adaptability. Gardens and cultivated terrains in humid to subhumid areas are their normal habitat. *S. asper* prefers a slightly cooler and more humid environment than *S. oleraceus*. They have no specific edaphic requirements. *S. malaianus* has been reported from tropical forests and roadsides at elevations above 1000 m in Sumatra and Java. *S. wightianus* occurs in humid places such as dikes of paddy fields and irrigation canals up to 3200 m altitude. All 4 species usually flower and fruit year-round.

Agronomy Propagation is mainly by seed, which is produced abundantly and dispersed readily by wind and water. Fragments of the rhizome of *S. wightianus* also easily sprout. *Sonchus* species are rarely cultivated in South-East Asia for vegetable use. Leaves are collected from plants growing in the wild. As a medicinal plant, *S. wightianus* is sown in a nursery; seedlings are transplanted one month from sowing at distances of 25–50 cm × 25–50 cm. To induce branching, plants are pruned to a height of 10–25 cm. Leaves are hand-picked at regular intervals, starting 2 months after transplanting. They are immediately dried in full sunshine for 2–3 days and stored in airtight containers. A dry leaf yield of 900–1200 kg/ha in 4–6 months has been reported.

Diseases like anthracnose (*Gloeosporium* spp.) and rust (*Puccinia sonchi-arvensis*) may decrease the healthy leaf area.

Genetic resources and breeding To date there has been no systematic germplasm collection or selection and breeding for *Sonchus* species.

Prospects *Sonchus* species are minor vegetable greens. Their medicinal applications may also stimulate their consumption as a vegetable. This applies in particular to *S. wightianus*. Any breeding work should focus first on reducing the bitterness.

Literature |1| Boulos, L., 1973. Révision systématique du genre Sonchus L. s.l. IV. Sous-genre 1. Sonchus [Systematic revision of the genus Sonchus L. s.l. IV. Subgenus 1. Sonchus]. Botaniska Notiser 126: 155–196. |2| Kurnia, Sasongko, E., Untari, E. & Sylvia S., 1975. A study on the dissolving capacity of Sonchus spp. and 4 species of keci beling on several calcium stones. Proceedings First Symposium on Medicinal Plant Research, Bogor, Indonesia. pp. 169–175. |3| Soediarto, 1973. Guide to the cultivation of jombang (Sonchus arvensis L.). Research Institute for Industrial Crops, Bogor, Indonesia, Circular No 7: 1–8. |4| Surohaldoko, S., 1983. Ecology of tempuyung (Sonchus arvensis L.) as a basis of its agronomy. Doctoral dissertation, University Gajah Mada, Yogyakarta, Indonesia. 200 pp. |5| Trimurti, 1985. Development morphology of the flower and fruit of Sonchus oleraceus L. End Project Report, Department of Biology, Institute of Technology, Bandung, Indonesia. |6| Tsun-Shih Hsieh, Schooler, A.B., Bell, A. & Nalewaja, J.D., 1972. Cytotaxonomy of three Sonchus species. American Journal of Botany 59(8): 789–796.

E.B. Hidajat

Sonneratia caseolaris (L.) Engler

Engler & Prantl, Nat. Pfl. Fam. Nachtr. 1: 261 (1897).

SONNERATIACEAE

$2n = 22, 24$

Synonyms *Rhizophora caseolaris* L. (1754), *Sonneratia acida* L.f. (1781), *S. obovata* Blume (1851).

Vernacular names Indonesia: pidada, perepat, bogem (Sundanese). Malaysia: pedada, berembang, perepat. Papua New Guinea: pagapate. Philippines: pagatpat (Tagalog), hikaw-hikawan (Tagalog), bunayon (Bisaya). Burma: tapoo, tamoo. Cambodia: 'âm'-piё. Thailand: lamphu (central). Vietnam: b[aaf]n chua.

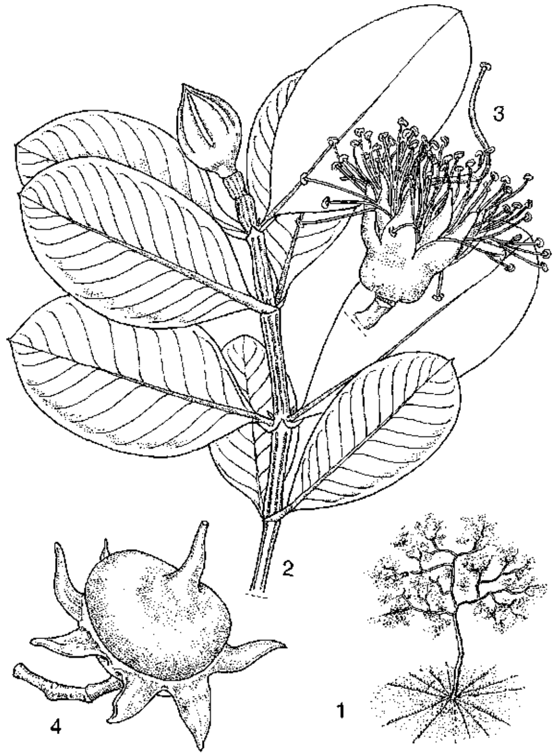
Origin and geographic distribution *S. caseolaris* is native to South and South-East Asia and is distributed from India and Sri Lanka up to southern China, and throughout South-East Asia to northern Australia and the western Pacific islands.

Uses The main use of *S. caseolaris* is as a fruit vegetable, although it is of minor importance. Young fruits have a sour taste and are used as a flavouring. Ripe fruits have a cheese-like taste and are eaten raw or cooked. Leaves are occasionally consumed, usually raw.
The fruits can be used medicinally, chiefly externally but also internally, in arresting haemorrhage, as a vermifuge and to soothe coughing. The leaves, pounded with salt, are used as a poultice and plaster on minor wounds. Pectin can be extracted from the fruits. The wood of *S. caseolaris* is of poor quality and is only occasionally used for pulp or fuel. The breathing roots (pneumatophores), after being boiled in water, yield an inferior substitute for cork. The bark contains 9–15% tannin (dry weight basis) and is locally used for tanning leather and nets.

Production and international trade The tree is known and used almost exclusively by inhabitants of coastal areas. No statistics are available on production and use.

Properties Data on the nutritional value are scarce. Ripe fruits are reported to contain per 100 g: water 80 g, protein 2.3 g, fat 1.0 g, carbohydrates 9.4 g, fibre 5.7 g, ash 1.6 g, P 50 mg, Ca 40 mg, Fe 0.9 mg. The corresponding energy value is 235 kJ/100 g.

Description Tree, 5–15(–20) m tall, trunk not buttressed, branches horizontal or drooping, crown lax. Root system consisting of extended cable roots giving rise to descending anchor roots and numerous erect, often branched, cone-shaped pneumatophores (breathing roots) extending 0.2–2.5 m above the substrate, and of numerous narrow feeding roots developing horizontally in the substrate. Bark flaky, greyish pale brown. Young branchlets quadrangular, occasionally 4-winged, with 2 pairs of glands. Leaves simple, opposite, entire, glabrous, leathery; leaf-blade elliptical, ovate or obovate, 4–13 cm × 2–7 cm, apex rounded, often with recurved mucro, veins not prominent; petiole 2–9 mm long, reddish; stipules absent. Flowers bisexual, terminal, either single or in groups of 2 or 3, 4–8-merous; pedicel short, often quadrangular; calyx tubular, 3–4.5 cm long, leathery, 5–8-lobed, persistent in fruit; petals always present, linear, 20–30 mm × 1–3 mm, red, early caducous; stamens numerous, inflexed in bud, early caducous, filaments reddish or rarely white, 2–3 cm long; ovary superior, sessile, 13–21-locular, style 4–6 mm long. Fruit a depressed-globose berry, 5–7.5 cm in diameter, 3–4 cm long, with fleshy pulp and leathery green, glossy pericarp, crowned by the style base, indehiscent, resting on the persistent calyx which is spreading and not enclosing the fruit. Seeds numerous, irregularly angular, ca. 7 mm long.



Sonneratia caseolaris (L.) Engler – 1, habit of tree with radiating pneumatophores; 2, shoot with flower bud; 3, flower; 4, fruit.

Growth and development Germination is epigeal. It is a pioneer species of mangrove swamps, and seeds will not germinate easily in shade. Seedling leaves are narrowly lanceolate, 12–13 cm × 1–5 cm; adult tree leaves are elliptical. Flowering in South-East Asia is year-round, noctural, and pollination seems to be effected by nectar-drinking bats or large night-moths. Stamens and petals fall from the flowers within 12 hours of opening. At anthesis, the flower emits a sour, buttery odour. During the main flowering period in Vietnam (March – April) the plant attracts thousands of fireflies which illuminate areas of mangrove.

Other botanical information Interspecific hybridization is fairly common in *Sonneratia*. *S. ×gulngai* N.C. Duke is a presumed hybrid between

S. alba J. Smith and *S. caseolaris*.

Ecology *S. caseolaris* is common in the inner parts of mangrove forests on deep muddy soils and extends inland along tidal creeks usually as far as the influence of salinity extends. Its characteristic habitat consists of river banks and tidal areas with mud banks, often in upstream estuarine positions of rivers subjected to large volumes of freshwater run-off. In some instances it has been found growing in fully fresh water without any connection with brackish water.

Agronomy *S. caseolaris* is propagated by seed. These are small and tend to float. Reforestation is usually by means of seedlings, planted at a spacing of 1 m × 1 m. Threatening diseases and pests have not been reported except mangrove crabs, which feed on leaves and may destroy seedlings.

Genetic resources and breeding No germplasm collections exist and no breeding programmes are being carried out.

Prospects *S. caseolaris* forms an element of mangrove forests, and that fact determines its greatest value. The biological basis for sustained use and management of such forests is still deficient. The safest policy minimizes direct utilization in order not to disturb this complex ecosystem. The use of *S. caseolaris* fruits as a vegetable is minor and should remain so until there is a safe management system for the sustained use of mangrove forests.

Literature |1| Backer, C.A. & van Steenis, C.G.G.J., 1951. Sonneratiaceae. In: van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 4. Noordhoff-Kolff, Djakarta, Indonesia. pp. 280–289. |2| Duke, N.C. & Jackes, B.R., 1987. A systematic revision of the mangrove genus Sonneratia (Sonneratiaceae) in Australasia. Blumea 32(2): 277–302. |3| FAO, 1985. Mangrove management in Thailand, Malaysia and Indonesia. FAO, Rome, Italy. pp. 29–39. |4| Tomlinson, P.B., 1986. The botany of mangroves. Cambridge University Press, Cambridge, United Kingdom. pp. 368–370. |5| Voon Boon Hoe, Patricia Sim & Chin Thian Hon, 1988. Sayur-sayuran dan buah-buahan hutan di Sarawak [Vegetables and fruits from the forest in Sarawak]. Department of Agriculture, Sarawak, Malaysia. p. 31. |6| Vu van Cuong, 1965. Sonneratiaceae. Sonneratia. In: Flore du Cambodge, du Laos et du Vietnam [Flora of Cambodia, Laos and Vietnam]. Vol. 4. Muséum National d'Histoire Naturelle, Laboratoire de Phanérogamie, Paris, France. pp. 194–203.

E.N. Sambas

Spilanthes Jacquin

Enum. Syst. Pl. Carib. 8: 28 (1760).
COMPOSITAE
x = unknown

Major species and synonyms

- *Spilanthes iabadicensis* A.H. Moore, Proc. Amer. Acad. Arts & Sci. 42: 542 (1907), synonym: *S. acmella* auct., non (L.) Murr.
- *Spilanthes paniculata* Wall. ex DC., Prodr. 5: 625 (1836), synonyms: *S. pseudo-acmella* auct., non (L.) Murr., *S. acmella* auct., non (L.) Murr.

Vernacular names Indonesia: jotang, jocong, daun getang. Malaysia: getang, kerabu. Philippines: biri (Igorot), dilag-dilag (Ifugao), gatang-gatang (Sulu). Laos: kh'aad. Thailand: phakkhrat (central), phakphet (northern), phaktumhu (peninsular). Vietnam: c[us]c n[us]t [as]o, c[us]c [as]o.

Origin and geographic distribution The genus *Spilanthes* comprises about 75 species, mainly in Central and South America. Approximately five species have been reported from South-East Asia, but their identification has been subject to much confusion, making many literature sources hard to interpret. *Spilanthes iabadicensis* and *S. paniculata* seem to be the major sources of edible leaves. Both species occur in South America but are also common weeds in the whole of South-East Asia, including Papua New Guinea.

Uses Young leaves and flower heads are eaten, the taste being rather pungent. The flower heads in particular strongly promote salivation. The leaves are eaten raw as well as boiled in Thailand and Indonesia. In Sundanese restaurants in West Java, young *Spilanthes* leaves are usually served raw with other fresh vegetables together with a chilli sauce ('sambal').
Several medicinal applications have been ascribed to *Spilanthes acmella* auct., non (L.) Murr. (referring variably to *S. iabadicensis, S. paniculata*, and even to other species such as the real para cress, *S. oleracea* L.). The most important application is the use of the flowerheads as a local anaesthetic, often applied to ease toothache.

Production and international trade *Spilanthes* greens are market vegetables in Thailand and Indonesia. They are gathered from naturally occurring stands, and traded and consumed locally.

Properties Per 100 g edible portion *Spilanthes* has been reported to contain: water 89–93 g, protein 2 g, fat 0.3 g, carbohydrates 3–7 g, Ca 162 mg, P 41 mg, Fe 4.0 mg, vitamin A 3900 IU, vitamin B_1 0.03 g, vitamin C 20 mg. The energy value is 96–134 kJ/100 g.

The anaesthetic properties of *Spilanthes* species are due to an essential oil which contains spilanthol.

Botany Annual or short-lived perennial herbs, erect or prostrate at the base and rooting at the nodes, upwards often strongly branched. Leaves opposite, simple, mostly dentate. Flower heads radiate or discoid, terminal or axillary from the upper leaves, usually solitary, erect. Fruit a small, dry, hard, 1-seeded achene.

- *S. iabadicensis.* Annual herb, 20–100 cm tall, erect or creeping. Stem angular, below the nodes with rather coarse, white, appressed hairs. Leaf-blade elliptical to ovate-elliptical, 1–10 cm × 0.5–6 cm, 3-nerved, chartaceous; base cuneate or contracted, margin subentire, undulate or undulate-dentate, apex acute or obtuse, apical margin slightly dentate-serrate; petiole 0.5–2 cm long. Flower heads radiate, elongate-ovoid, 5–6 mm × 7–11 mm; peduncle increasing in length after flowering, 1–12 cm long, angular, thickened apically; involucral bracts 5–7, in one row. Ray flowers usually 5 in one row, female; corolla white or bright yellow, 2–2.5 mm long. Disk flowers numerous, bisexual; corolla bright yellow, 1.3–1.5 mm long, 4–5-lobed; anther tube not exserted, brown; ovary compressed, style with 2 short arms. Achene ellipsoid, 1–1.5 mm long, truncate, black, with 2 remote, erect, thin, very short pappus bristles.
- *S. paniculata.* Differs from *S. iabadicensis* mainly in the following aspects. Leaf-blade broadly ovate to ovate-triangular, 1–12 cm × 0.5–7 cm. Involucral bracts 8–14, in 2 rows. Peduncle up to 16 cm long. Flower heads radiate or conical, 10–15 mm × 8–11 mm. Ray flowers (0–)5(–12). Achene 2–3 mm long. A form with two-coloured heads in which young disk flowers are violet at apex has been named f. *bicolor* Koster.

Spilanthes paniculata Wall. ex DC. – flowering and fruiting shoot.

Both species are reported to hybridize easily, giving rise to intermediate, though sterile, forms.

Ecology *S. iabadicensis* occurs by preference in moist or swampy localities, in rice fields ('jotang sawah' in Indonesia) and on dikelets, along pools and ditches, in moist gardens and marshy meadows. In Java it occurs up to 1500 m altitude, in Papua New Guinea up to 500 m.

S. paniculata grows in drier places than *S. iabadicensis*, such as upland fields ('jotang huma' in Indonesia), waste places, roadsides, and riversides. In Java it occurs up to 1200 m altitude, in Papua New Guinea up to 300 m.

Both species flower year-round and produce plenty of seed which is dispersed by animals and wind.

Agronomy There are no reports on deliberate cultivation of *Spilanthes* greens. They are weeds of minor agricultural importance.

Prospects *Spilanthes* greens will remain of minor importance as vegetables. Being agricultural weeds, efforts will be directed more towards eradication than multiplication.

Whether *Spilanthes* has potential as medicine needs further investigation.

Literature |1| Jacquat, C., 1990. Plants from the markets of Thailand. Editions Duang Kamol, Bangkok, Thailand. pp. 91–92, 180. |2| Koster, J.Th., 1979. The Compositae of New Guinea 6. Blumea 25: 249–282. |3| Perry, L.M., 1980. Medicinal plants of South-East Asia. The MIT Press, London, United Kingdom. pp. 98–99. |4| Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G., 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. pp. 102–105. |5| Unus Suriawiria, 1987. Lalab dalam budaya dan kehidupan masyarakat Sunda [Lalab in the culture and life of Sundanese society]. Granesia, Bandung, Indonesia. 129 pp.

Roemantyo

Spinacia oleracea L.

Sp. pl.: 1027 (1753).
CHENOPODIACEAE
$2n = 12$

Vernacular names Spinach (En). Epinard (Fr). Indonesia: peleng, puileng, horenso (from Japanese). Philippines: sosolon a gadong a kamo (Marinduque). Thailand: puaileng (central). Vietnam: rau nh[af] ch[uf]a, b[os] x[oo]i.

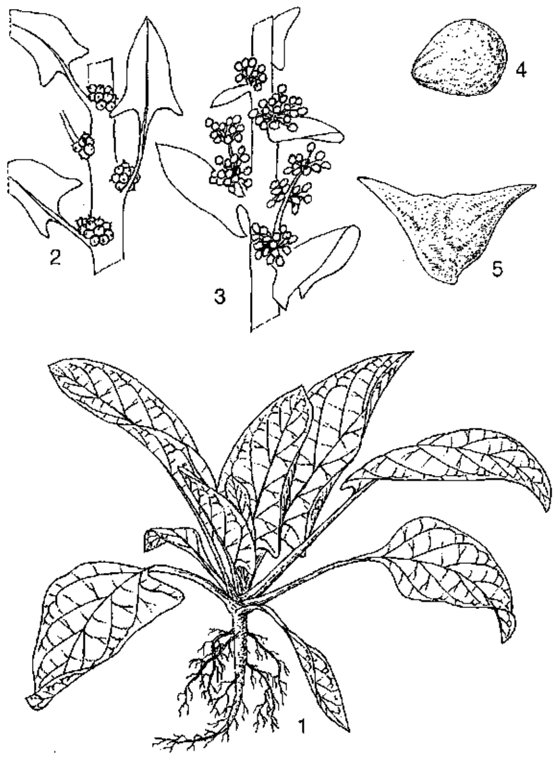
Origin and geographic distribution Spinach is not known in a wild state. Probably it originated in North Iran, Afghanistan, and Turkmenistan where related wild species such as *Spinacia tetrandra* Steven and *S. turkestanica* Iljin still exist. It spread to China around 600 AD and from there to Korea and Japan in the 14th to 17th Centuries. In Europe it became a popular vegetable after 1200 AD. Now spinach is cultivated worldwide in temperate areas and in the cooler parts of the tropics.

Uses Spinach is an important green leafy vegetable in temperate climates. In Asia it is almost entirely a fresh market product consumed after light cooking, while in western Europe and North America more than half is processed into a deep-freeze product.

Production and international trade The area annually cultivated to spinach is as follows: western Europe 25000 ha, North America 20000 ha, Japan 26000 ha, Korea 70000 ha. The area in China is large but no precise data are available. In South-East Asia it is gaining in importance with the availability of well-adapted cultivars of Japanese origin. In Indonesia spinach is grown to a limited extent in the highlands of Java (above 1200 m) and sold to an expatriate clientele (Japanese, Taiwanese, Korean). Spinach from the Cameron Highlands (Malaysia) is exported to Singapore.

Properties Spinach has a high nutritional value and is a good source of minerals and vitamins. Per 100 g fresh leaves it contains: water 91.6 g, protein 2.5 g, carbohydrates 3.4 g, Ca 125 mg, Fe 4.1 mg, ß-carotene 4.1 mg, vitamin B complex 0.9 mg, vitamin C 52 mg. The energy value is 100 kJ/100 g. It also contains oxalic acid and free nitrates, but these are not considered harmful when average consumption is less than 100 g spinach per day. The 1000-seed weight is 9–13 g.

Description Annual, glabrous, dioecious herb, 20–150 cm tall with a long taproot. Leaves form a rosette (25–50 cm in diameter and 10–20 cm high) of 12–20 leaves clustered at ground level. Leaves spirally arranged, simple, no stipules; leaf-blade angular-ovate or arrow-head shaped with round to sharply pointed basal lobes, 9–30 cm × 7–20 cm, smooth or savoyed (crumpled) surface, light to dark green in colour; petiole 6–12 cm long, at base green, pink or purple-red. Inflorescence 80–150 cm high, branching, angular-ribbed, bearing small oblong leaves; female flowers in numerous axillary clusters of 7–20 sessile flowers; male flowers arranged in 1–10 cm long spikes, often combined into a leafy panicle; sometimes both sexes occur on the same plant; flowers small with a green, 4-lobed perianth; stamens 3–5 in male flowers, 4–6 filamentous stigmas on a superior ovary with one ovule in female flowers; hermaphrodite flowers have a pistil and 1–2 anthers; the green anthers swell and turn yellow a day before anthesis; the perianth of female flowers grows out to a hard shell tightly enveloping the fruit. Fruit an utricle,



Spinacia oleracea L. – 1, habit; 2, shoot with female inflorescences; 3, shoot with male inflorescences; 4, round seed; 5, prickly seed.

indehiscent, teeth of perianth sometimes developing into prickles. Seed dull, obtusely margined.

Growth and development Spinach is normally dioecious with almost equal proportions of male and female plants, but many gradations of monoecism and hermaphroditism are known. In horticulture, the fruit of spinach (utricle) is usually called the seed. Dry spinach seed will remain viable for 2–3 years at ambient temperatures and 5–6 years when stored at 5°C and 30% relative humidity. Germination is epigeal. Depending on season and genotype, seedlings emerge 6–20 days after sowing and 35–100 days later the rosette is fully grown with the first signs of the flower stalk. Spinach is wind-pollinated. Seeds are mature about 60–70 days after flowering when plants quickly senesce and die off.

Other botanical information Asian-type spinach cultivars are fast-growing and quick-bolting, have arrow-head shaped, thin and smooth leaves, long petioles which are purple-red at the base, and often prickly seeds. Leaves should be dark green according to Japanese and light green to Chinese preferences. European cultivars vary from quick-growing light green winter to slow-bolting dark green summer types with thick, ovate, shortly petioled leaves, green or pink at the basal end.

Many cultivar classifications exist, based on leaf and seed (fruit) characteristics. A major division is into cultivars with prickly seed (2–4 spines), also classified as var. *oleracea*, and cultivars with non-prickly, globose or round seed, also classified as var. *glabra* (Miller) Moench.

Ecology Asian spinach cultivars, being adapted to short-day autumn or winter seasons, bolt readily in response to photoperiods of 12–14 hours. In Europe spinach is grown mostly in early spring and summer (north-western Europe) and requires a daylength of at least 14 hours for stem and flower formation. Optimum growing temperatures are 15–20°C, but spinach is tolerant of low temperatures (3°C) and even of light frost in some winter types. Vegetative growth is retarded by temperatures in excess of 27°C. Soils should be light in texture, fertile, well-drained, rich in organic matter and with a pH 6–7.5.

Agronomy Spinach needs high doses of N and K fertilizers as well as a regular water supply throughout the season for optimum yield and quality. Seed rates in Asia are 15–25 kg/ha.

The most important disease is downy mildew (*Peronospora farinosa* f.sp. *spinaciae*). Control by fungicides is difficult. Host resistance to all 4 physiological races will soon be available in modern F_1 hybrids. Cucumber mosaic virus (CMV) is especially important in warm and humid conditions; chemical control of the vector aphids (*Aphis fabae* and *Myzus persicae*) reduces incidence. *Fusarium* decline (*F. oxysporum* f.sp. *spinaciae*) and white rust (*Albugo occidentalis*) are particularly important in the United States. Seedling damping-off caused by *Pythium* spp. and *Rhizoctonia* spp. can be prevented by seed-dressing with fungicides. Pests include aphids and nematodes (*Ditylenchus dipsaci*).

Whole plants with 8–10 leaves are harvested, the roots are cut one cm below the plant base and the product is sold in bundles of 10–15 plants. In Europe and North America spinach for the fresh market is harvested by mowing the crop just above ground level at a young stage (seed rates 100–200 kg/ha) and spinach for the processing (deep-freezing) industry just at the first sign of flower stalk formation (seed rates 40–50 kg/ha). Yields vary from 10 t/ha in Asia to 35 t/ha for summer crops in Europe and the United States.

Genetic resources and breeding Working collections and germplasm of *Spinacia* spp. are present in some research centres in Europe (Wageningen, the Netherlands), the United States and Japan.

Present breeding programmes aim at F_1 hybrid cultivars between highly female monoecious and highly male monoecious lines. Sex expression is controlled by an X/Y heterosomal system and two strongly linked autosomal genes. The main breeding objectives depend on type and season: fast growth and slow bolting, high yields, round seed, resistance to downy mildew, cucumber mosaic virus and other diseases, dark green leaf colour, erect leaves (especially for Asian types), better heat tolerance.

Prospects Spinach will continue to be a very important leafy vegetable, and improved heat tolerance promotes its distribution to the warmer climates of Asia.

Literature |1| Bose, T.K. & Som, M.G. (Editors), 1986. Vegetable crops in India. Naya Prokash Press, Calcutta, India. pp. 655–669. |2| Parlevliet, J.E., 1968. Breeding for earliness in spinach (Spinacia oleracea L.) as based on environmental and genetic factors. Euphytica 17: 21–27. |3| Shinohara, S., 1984. Vegetable seed production technology of Japan. Vol. 1. Shinohara's Authorized Agricultural Consulting Engineer Office, Tokyo, Japan. 432 pp. |4| Sneep, J., 1982. The domestication of spinach and the breeding history of its varieties. Euphytica 1982, Supplement 2. 27 pp.

H.A.M. van der Vossen

Talinum triangulare (Jacq.) Willd.

Sp. pl. 2: 862 (1799).
PORTULACACEAE
$2n = 48, 72$

Synonyms *Portulaca triangularis* Jacq. (1760), *P. racemosa* L. (1762), *Talinum racemosum* (L.) Rohrb. (1872).

Vernacular names Waterleaf, Surinam purslane, sweetheart (En). Grassé (Fr). Indonesia: poslen (West Java), krokot belanda. Papua New Guinea: kumu manus. Philippines: talilong (Tagalog), galaghati (Subanon), biala (Marinduque). Thailand: som-kaoli (Bangkok), som-khon (Bangkok), som-chin (northern). Vietnam: th[oor] nh[aa]n s[aa]m.

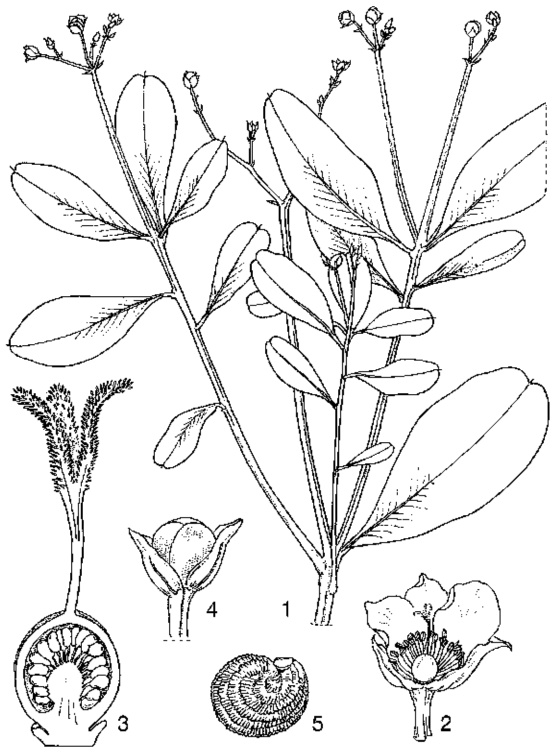
Origin and geographic distribution Waterleaf is probably native to tropical America. Its complete native range, however, is difficult to ascertain because it is easily transported and easily naturalizes. Waterleaf has become a weed with pantropical distribution, still extending its range. It was introduced into Java in 1915 from Surinam by the Bogor Botanic Gardens. Elsewhere in South-East Asia its introduction is also relatively recent.

Uses The leaves and shoots are usually consumed as a cooked (boiled or steamed) vegetable. They are rather soft and mucilaginous and should not be cooked for long. They are also added raw to salads in the Sundanese cuisine in West Java. It is a good alternative for purslane (*Portulaca oleracea* L.).
In South-East Asia waterleaf is sometimes planted as an ornamental pot plant or as an edging plant in gardens. In South America it has some medicinal applications. The crushed plant is applied as a poultice on contusions, inflammations and tumours. Decoctions are used for painful eyes and to aid recovery from blows and falls.

Production and international trade In Africa, South America and the Caribbean, waterleaf is a popular leafy vegetable. In South-East Asia it is a rather recent introduction and is still of minor importance. No statistics are available.

Properties Per 100 g edible portion, waterleaf contains: water 90–92 g, protein 1.9–2.4 g, fat 0.4–0.5 g, carbohydrates 3.7–4.0 g, fibre 0.6–1.1 g, ash 2.4 g, Ca 90–135 mg, Fe 4.8–5.0 mg, ß-carotene 3 mg, vitamin B_1 0.08 mg, vitamin B_2 0.18 mg, niacin 0.30 mg, vitamin C 31 mg. The energy value is 105 kJ/100 g. Waterleaf has a rather high oxalate content. The weight of 1000 seeds is 0.3 g.

Botany Erect perennial herb with swollen roots and obtuse-angular to terete, glabrous, succulent stems, 30–100 cm tall. Branches with 2 lateral, basal buds. Leaves spirally arranged to nearly opposite, often crowded at the top of the stem, indistinctly or shortly petioled; leaf-blades usually spathulate, 3–15 cm × 1–6 cm, entire and succulent, obtuse to rounded and occasionally notched at the apex. Inflorescence a long peduncled, terminal, corymboid thyrsus, 5–30 cm long, with 2–5 erect, sharply triangular axes, each 8–28-flowered; flowers bisexual, 0.5–2.5 cm in diameter; pedicels elongate after anthesis; sepals 2, free, green, persistent; petals 5, obovate, up to 10 mm × 4 mm, pink; stamens 20–40; style 2–3-fid, ovary superior. Fruit capsular, ellipsoid to globular, 4–7 mm long, 2–3-valved and elastically dehiscent,



Talinum triangulare (Jacq.) Willd. – 1, flowering and fruiting shoot; 2, flower (longitudinal section); 3, pistil (ovary in longitudinal section); 4, fruit; 5, seed.

yellow. Seeds numerous, compressed globose-reniform, 0.8–1.2 mm long, granulate, glabrous, shining black.
Waterleaf is fast-growing, and once established it easily reseeds itself. It flowers early and year-round, and is mainly self-pollinating. Flowers are open in the morning.
T. triangulare is most easily distinguished from *T. paniculatum* (Jacq.) Gaertner (a pantropical weed, primarily used as ornamental but also occasionally consumed as vegetable in South-East Asia) by its sharply triangular flowering axes (terete in *T. paniculatum*).

Ecology Waterleaf occurs naturally on roadsides, waste places, and forest edges, from sea-level up to 1000 m. It has a C4-cycle photosynthetic pathway, resulting in a high level of dry matter production under hot tropical conditions. It possesses a remarkable degree of drought tolerance. For good production it needs a soil rich in humus or heavily manured, and adequate moisture.

Agronomy Waterleaf is usually propagated by seed. However, the small seeds are rather difficult to collect because the fruits readily dehisce. Seeds are broadcast, direct-seeded in rows, or sown in a seed box and transplanted. The delicate seedlings must be shaded and mulched. Waterleaf can also be propagated vegetatively. Cuttings 15–20 cm long are taken from mature stems which have been stripped of leaves. Plant densities vary from 10–25 plants/m^2 depending on harvesting method and crop duration. Waterleaf flowers early but this seems to have little negative effect on leaf production. No serious diseases or pests are known.
Harvesting starts about 6–8 weeks after sowing, either by uprooting or by cutting the young tops. 15–20 harvests (at intervals of 2 weeks) can be made, but it is usually advisable to renew the planting after about six months. Yields have been estimated at 10 kg per m^2 per year (15–20 harvests). Seed yields are low and amount to 100–300 kg/ha. Seed production in untopped plants reaches a peak about 10 weeks after sowing.

Genetic resources and breeding No substantial germplasm collections exist. A few landraces have been collected in the Philippines and are being maintained at the National Plant Genetic Resources Laboratory, Institute of Plant Breeding, Los Baños. No breeding work has been carried out.

Prospects Waterleaf, with its slimy texture, is a popular vegetable in many African countries. It spreads easily and is becoming a general, though rather innocent, agricultural weed. Agronomic research and breeding work should be done on this interesting vegetable.

Literature |1| Geesink, R., 1971. Portulacaceae. In: van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 7. Noordhoff International Publishing, Leyden, the Netherlands. pp. 123–125. |2| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 620–621. |3| van Epenhuijsen, C.W., 1974. Growing native vegetables in Nigeria. FAO, Rome, Italy. pp. 92–94. |4| van der Zon, A.P.M. & Grubben, G.J.H., 1977. Les légumes-feuilles spontanés et cultivés du Sud-Dahomey [Wild and cultivated leaf vegetables of South Dahomey]. Communication 65. Department of Agricultural Research, Royal Tropical Institute, Department of Agricultural Research, Amsterdam, the Netherlands. Communication 65. pp. 97, 99.

M.A. Rifai

Tetragonia tetragonioides (Pallas) O. Kuntze

Rev. Gen.: 264 (1891).
AIZOACEAE
$2n = 32$

Synonyms *Demidovia tetragonioides* Pallas (1781), *Tetragonia expansa* Murrey (1783).

Vernacular names New Zealand spinach, warrigal cabbage (En). Tétragone cornue, épinard d'été (Fr). Indonesia: kabak. Malaysia: kabak. Philippines: ispinaka (Tagalog). Vietnam: d[eef]n t[aa]y, gi[eef]n t[aa]y.

Origin and geographic distribution *T. tetragonioides* was discovered during Captain Cook's voyages as a good pot herb and antiscorbutic plant of the Southern Hemisphere. It occurs wild in the coastal regions of Australia, Tasmania, New Zealand, the Pacific Islands, Japan, China and Taiwan. It was successfully tried out as a vegetable in Europe in the early 19th Century and has been introduced into most temperate and subtropical regions. In South-East Asia, it is grown at higher elevations, e.g. in Puncak and Brastagi (Indonesia) and Baguio (the Philippines).

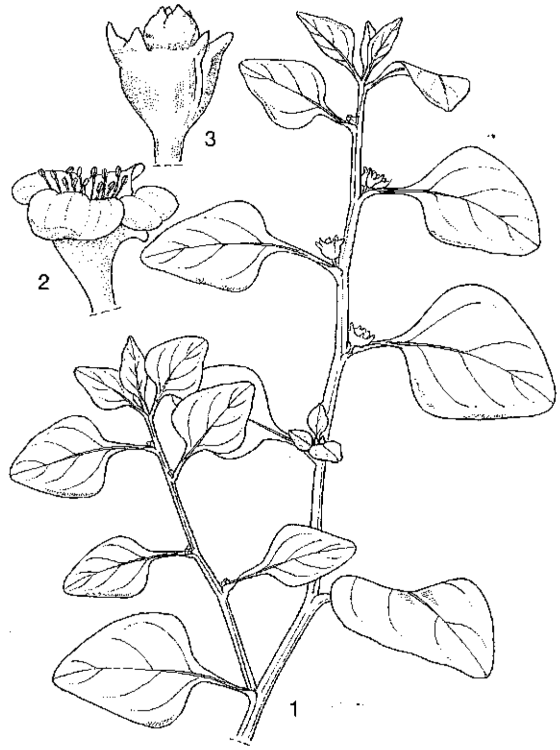
Uses New Zealand spinach is usually consumed boiled. As the leaves tend to taste slightly bitter, it is advisable to blanch them before cooking. The leaves are, however, also used raw as an ingredient of salads. They are suitable for deep-freezing like ordinary spinach (*Spinacia oleracea* L.).

Production and international trade New Zealand spinach has never become an important commercial vegetable in temperate areas due to the labour-intensive harvest. It is grown mainly as a small-scale home garden crop, and production data are not available. In Indonesia it is mainly traded to the supermarkets of the big cities.

Properties New Zealand spinach is known as a good source of minerals, in particular Ca and Fe, and of vitamins. Per 100 g edible portion, it contains: water 93 g, protein 1–2 g, fat 0.3 g, carbohydrates 3–5 g, Ca 58–180 mg, Fe 2.5–3.8 mg, ß-carotene 4.3 mg, vitamin B_1 0.08 mg, vitamin B_2 0.20 mg, niacin 0.5 mg, vitamin C 25–50 mg. The energy value is 80 kJ/100 g. It has been reported that most Ca is present as oxalates, not available to the human body. Consumption as a raw vegetable has also been discouraged because of a high saponin content. The 1000-fruit weight is 65–100 g.

Botany Fleshy, strongly branched, xerophytic, annual herb, covered all over with minute, shining, white papillae. Stems erect when young, afterwards trailing-ascending, terete or slightly angular, up to 1 m tall. Leaves succulent, spirally arranged; leaf-blade ovate-rhomboid-triangular, 1.5–11 cm × 1–7.5 cm, entire, dark green above, pale green beneath, dull on both sides; petiole 0.5–2.5 cm. Flowers bisexual, axillary, solitary or 2–3 together; perianth-tube turbinate, 1.5–2 mm long during anthesis, under each segment with a short hornlet, enlarging after anthesis; segments (3–)4(–5), 2–3 mm long, unequal, green externally, yellowish-green inside; stamens 4–10, filaments yellow; ovary semi-inferior, 2–9-celled, styles as many as cells. Fruit a conical, obconical or globular drupe, 2–5-horned, 2.5–12.5 mm long, 4–10-seeded, indehiscent. Seed subreniform.

Sowing 'seed' usually consists of dry, hard fruits, each containing several true seeds. The 'seeds' are reported to germinate erratically, taking from 2 weeks to more than 3 months. New Zealand spinach is a vigorous spreading plant developing a short upright shoot, and several radiating branches from its base, which lie prostrate on the ground. The plant flowers and fruits readily, with little apparent negative effects on growth. New Zealand spinach is predominantly self-pollinated, but cross-pollination may occur. The indehiscent fruits fall on the ground on ripening, the crop reseeding itself. Planting material (seeds or fruits) is usually traded without cultivar names.



Tetragonia tetragonioides (Pallas) O. Kuntze – 1, flowering and fruiting shoot; 2, flower; 3, fruit.

Ecology New Zealand spinach occurs naturally in coastal areas. As a xerophyte it is capable of enduring long periods of drought. In the tropics it is easier to grow then *Spinacia oleracea* because of its better heat tolerance. The succulent leaves do not transpire rapidly.

In South-East Asia, it is grown mainly at elevations of 1000–1700 m, but with good care it can also be grown in the lowlands. A fertile, sandy, well-drained soil gives the best results.

Propagation and planting New Zealand spinach is grown from seed, which is easily obtained, even under tropical conditions. Seeds should preferably be soaked in water for an hour to soften the seed-coat. Seedlings are usually raised in nurseries and transplanted when they have 6–7 leaves into permanent beds at distances of 50–100 cm either way. Soaked fruits (containing several true seeds) can also be direct-'seeded'. Propagation by stem cuttings is rarely practised.

Husbandry To obtain rapid, tender growth, manure and complete fertilizer should be amply supplied. A nitrogen fertilizer is advantageous as a side dressing to stimulate regrowth after harvesting. 30 t/ha of harvested shoots contain approximately 60 kg N, 15 kg P_2O_5 and 105 kg K_2O, and therefore the total fertilizer application per ha should be 100 kg N, 25 kg P_2O_5 and 150 kg K_2O. Because initial growth is slow, New Zealand spinach can best be grown in alternating rows with other, quick-maturing vegetables. Once fully developed, one plant easily covers 1 m^2 of ground surface.

Diseases and pests New Zealand spinach is relatively little affected by diseases and pests. Rot of the prostrate stems may occur, but this is insignificant on sandy soils. Old plants may degenerate by virus. Leafhoppers and aphids are sometimes troublesome. The root system is attacked by root knot nematodes.

Harvesting When the central stem has grown to a height of 15 cm and the branches to a length of 15–20 cm, tops of 5–7.5 cm length may be cut for the first harvest (2–3 months after sowing). As the plant spreads over the soil, harvesting of new shoots may continue at weekly intervals over a period of several months. When regularly cut back, it may persist in the tropics as a short-lived perennial.

Yield Yield can be 1.5 kg/plant or 30 t/ha. When growth becomes unsatisfactory, the mat of old plants may be pulled out, and the young plants which are developing underneath from fallen fruits, may be used for a new crop.

Handling after harvest The leaves do not store well. They should be consumed soon after harvest or stored at 0°C and 95% relative humidity.

Genetic resources and breeding There are no germplasm collections. Genetic improvement of the crop has not been undertaken to any significant degree.

Prospects New Zealand spinach is an easy to grow, nutritious vegetable and deserves a corner in any tropical vegetable garden. Due to its spreading habit, a few plants are sufficient for a regular supply. It is drought resistant, salt tolerant, and immune to most insect pests.
In temperate regions it has not been able to compete with the ordinary spinach because of the amount of labour involved in harvesting compared to the once-over harvest in *Spinacia oleracea*.

Literature |1| Backer, C.A., 1951. Aizoaceae. Tetragonia. In: van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 4. Noordhoff-Kolff, Djakarta, Indonesia. p. 275. |2| Buishand, T., 1977. Groentetuin voor iedereen [Vegetable garden for anyone]. Kosmos, Amsterdam, the Netherlands. p. 279. |3| Fritz, D., Stolz, W., Venter, F., Weichmann, J. & Wonneberger, C., 1989. Gemüsebau [Vegetable growing]. 9th revised edition. Ulmer, Stuttgart, Germany. pp. 307–308. |4| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 388–391.

J.S. Siemonsma

Trichosanthes L.

Sp. pl.: 1008 (1753); Gen. pl. ed. 5: 439 (1754).
CUCURBITACEAE
$x = 11$; $2n = 22$ (*T. cucumerina*)

Major species and synonyms

- *Trichosanthes celebica* Cogn., Monogr. phan. 3: 385 (1881).
- *Trichosanthes cucumerina* L., Sp. pl.: 1008 (1753), synonyms: *T. anguina* L. (1753), *T. cucumerina* L. var. *anguina* (L.) Haines (1922).
- *Trichosanthes ovigera* Blume, Bijdr.: 934 (1826), synonyms: *T. cucumeroides* (Seringe) Maxim. (1875), *T. himalensis* C.B. Clarke (1879).
- *Trichosanthes villosa* Blume, Bijdr.: 934 (1826), synonym: *T. kerrii* Craib (1914).

Vernacular names

- *T. celebica*. Indonesia: tawuruk, amut tamburuk (Sulawesi). Malaysia: akar tiga chabang, chabang tiga, mentimun dendang (Peninsular).
- *T. cucumerina*. Snake gourd (En). Serpent végétal (Fr). Indonesia: paria belut, paria ular, pare welut (Javanese). Malaysia: ketola ular, timun bengkok, petola ular (Peninsular). Philippines: pakupis, tabubok (Tagalog). Laos: ngoo ngèèwz. Thailand: buap ngu, nom phichit (central), ma noi (northern). Vietnam: d[aa]y na t[aa]y, d[uw]a n[us]i, m[uw][ows]p t[aa]y.
- *T. ovigera*. Indonesia: areuj tiwuk (Sundanese). Vietnam: hoa b[as]t.
- *T. villosa*. Indonesia: areuj baduyut, waluh leuweung (Sundanese). Philippines: kandolamo (Bukidnon). Laos: cho' tau quân. Vietnam: d[aa]y d[or] m[or].

Origin and geographic distribution The genus *Trichosanthes* is native to southern and eastern Asia, including South-East Asia, and to Australia and the western Pacific. Although the genus is poorly known taxonomically, it is thought to comprise about 40 species, about 15 of which are present in South-East Asia.

- *T. celebica* is only known wild from Peninsular Malaysia and Sulawesi.
- *T. cucumerina* occurs wild in the whole area of

the genus and in the same area it is also of ancient cultivation. Its domestication may have started in India. Only occasionally is it cultivated in other tropical or subtropical areas. As vegetable it is the most important *Trichosanthes* species.

- *T. ovigera* occurs wild in the whole area of the genus but is probably most important in China and Japan. It is possibly also cultivated occasionally.
- *T. villosa* occurs wild in Java, the Philippines, Thailand and Indo-China.

Uses

- *T. celebica*. Leaves are eaten cooked as a vegetable. They are also used as a substitute for soap and when smeared on the skin are reputed to repel mosquitoes.
- *T. cucumerina*. Immature fruits of cultivated forms are eaten boiled as a vegetable or in curries. Young shoots and leaves are also edible. In some forms, all young parts have an unpleasant smell and taste bitter but these characteristics disappear after boiling. The fruits become inedible upon ripening: they taste bitter and develop hardened fibrovascular bundles like the loofahs. In West Africa the red fruit pulp is used as a kind of cheap tomato paste. Fruits of the wild forms are very bitter and inedible. They are used in traditional medicine as a purgative and vermifuge. A kind of cough syrup is prepared from the pulp.
- *T. ovigera*. Boiled fruits are eaten as a side-dish with rice. In China and Japan the starch of the tubers is sometimes extracted.
- *T. villosa*. Young fruits are eaten boiled as a vegetable. Sap from the leaves is used to cure dysentery; pounded leaves are applied on the body to reduce fever and alleviate the pain of swollen legs.

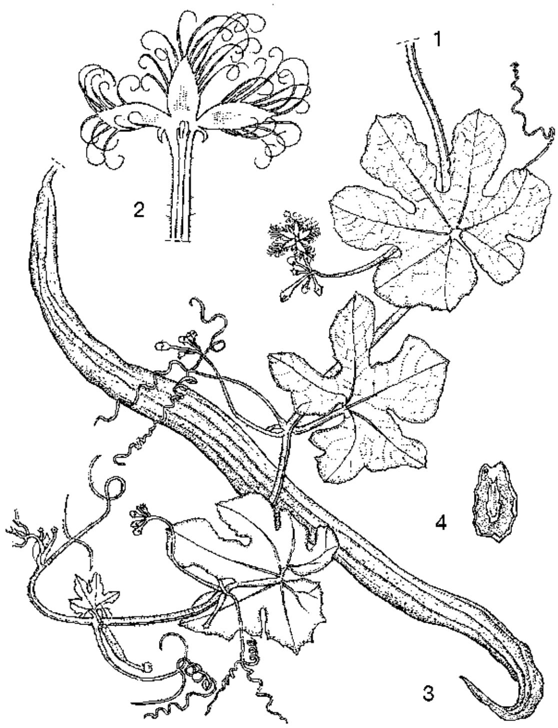
Production and international trade Snake gourd is mainly grown as a home garden crop for own consumption or for the local market. No statistics are available. The wild edible species are collected and consumed locally only.

Properties The edible part of the immature fruits of snake gourd is 86–98%. Per 100 g edible portion it contains: water 94 g, protein 0.6 g, fat 0.3 g, carbohydrates 4 g, fibre 0.8 g, Ca 26 mg, Fe 0.3 mg, P 20 mg, vitamin A 235 IU, vitamin B_1 0.02 mg, vitamin B_2 0.03 mg, niacin 0.3 mg, vitamin C 12 mg. The energy value is approximately 70 kJ/100 g.

All species produce the purgative glucoside elaterin in their tissues, the amount of which increases as the fruit ripens. Seed oils of *Trichosanthes* species consistently have major proportions of punicic acid.

Description Annual or perennial, monoecious or dioecious, climbing or trailing herbs. Tendrils simple or 2–5-fid. Leaves alternate, simple, unlobed or palmately 3–9-lobed or compound. Male flowers in axillary racemes, rarely solitary; calyx tubular, 5-lobed; corolla 5-lobed, the lobes fringed with hairlike outgrowths, usually white; stamens 3, anthers free or united, 2 bilocular, 1 unilocular. Female flowers solitary; perianth as in male flowers; stigmas 3, entire or bifid. Fruit a fleshy, indehiscent berry (pepo), containing numerous seeds. Seed generally flattened.

- *T. celebica*. Leaves coriaceous, trifoliolate; petiole 2–3 cm long; leaflets unequal, mid-one largest, ovate-oblong, 7–12 cm × 3.5–6 cm. Fruit ovoid to oblongoid, 10–15 cm × 7–8 cm, red. Seed brown with thick margin.
- *T. cucumerina*. Monoecious annual with 5-angled, furrowed, slender stem. Tendrils 2–3-branched. Leaves simple, more or less deeply 5–7-lobed or angular, 7–25 cm × 8–20 cm, cor-



Trichosanthes cucumerina L. – 1, flowering and fruiting shoot; 2, top of female flower (longitudinal section); 3, fruit; 4, seed.

date at base, margins dentate, pubescent; petiole 2–10 cm long, furrowed, succulent, scabrid hairy. Male flowers on 10–30 cm long peduncles, 5 to many flowers together. Female flowers sessile. Fruit very slender, long cylindrical, often twisted, 30–180 cm × 2–10 cm, much smaller in wild forms, greenish-white when immature, dark red when mature. Seed thick, 1–1.5 cm long, brown, sculptured, margin undulate.

- *T. ovigera*. Dioecious perennial herb with tuberous roots. Tendrils 2-branched. Leaf-blade broadly ovate to suborbicular, 7–15 cm × 6–15 cm, unlobed to deeply 3–5-lobed, scabrid above, pubescent beneath; petiole 2–6 cm long. Male flowers in 4–12-flowered racemes 6–20 cm long; peduncle 3–10 cm long with dentate, obovate, 5–10 mm long bracts; pedicel 0.5–2 cm long. Female flowers on 2–3 cm long pedicel. Fruit ovoid to ellipsoidal, 8–10 cm × 2.5–3 cm, red when mature. Seed 3-locular, 6–8 mm long, grooved, brown.
- *T. villosa*. Dioecious herb with angular stem. Tendrils 3–5-branched. Leaf-blade ovate-orbicular, 10–16 cm × 5–18 cm, entire or acutely 3-lobed, pubescent above, densely soft hairy beneath; petiole 6–8 cm long. Male flowers in 10–20 cm long racemes; bracts entire, 3–4 cm × 1–1.5 cm; pedicel 2–3 cm long. Female flowers on 1.5 cm long pedicel. Fruit ellipsoid-globose, 8–13(–30) cm in diameter, yellow to red at maturity, fruit stalk robust. Seed flattened obovoid, about 2 cm × 1 cm × 0.5 cm.

Growth and development Flowering of snake gourd starts about 5 weeks after planting; the male flowers appear first, followed by the female flowers about 3 days later. The flowers open in the evening or in the early morning. Anthers dehisce several hours before anthesis, stigmas are receptive from a few hours before anthesis to a few hours after. Pollination is effected by insects. In early-maturing cultivars the first young fruits are harvestable about 7 weeks after planting, and picking may be continued for 1–2 months.

Other botanical information The genus *Trichosanthes* is poorly known and needs a thorough taxonomical revision. The snake gourd has been considered a separate species (*T. anguina*); now it is believed to be a cultivated form of *T. cucumerina* which can best be classified as a cultivar group (e.g. cv. group Snake Gourd) consisting of several cultivars. The traditional botanical classification of the cultivated and wild forms in different varieties (*T. cucumerina* L. var. *anguina* (L.) Haines and var. *cucumerina* respectively) or subspecies (ssp. *anguina* (L.) Grebenscikov and ssp. *cucumerina*) must be rejected.

Ecology Snake gourd is well adapted to the humid tropical lowlands. It does not tolerate dry soil and requires a good moisture reserve in the soil, but it is also sensitive to waterlogging. The optimum average temperature for growth is 30–35°C, with a minimum of 20°C.

The wild species can be found in scrub, along forest edges and in open forest, up to 1000(–1500) m altitude.

Propagation and planting Snake gourd is propagated by seed, requiring 4–6 kg/ha. Seed can be sown in a nursery and transplanted at the 2-true-leaf stage but usually it is sown in situ in planting holes or on ridges 1–1.5 m apart, 60–75 cm between plants.

Husbandry Snake gourd plants require support from poles or a trellis (in home gardens the plants are often trailed over thatched huts or over walls) so that the fruits can hang vertically. A weight is usually hung onto the tip of the growing fruit to keep it straight. Usually the crop receives little attention. Response to manuring and fertilizer application is good, but if too much nitrogen is applied vine growth is excessive. Female to male flower ratio can be improved by pruning. In seasonal climates frequent irrigation may be necessary during the dry season.

Diseases and pests The most serious diseases of snake gourd are downy mildew (*Pseudoperonospora cubensis*) and anthracnose (*Colletotrichum lagenarium*). Repeated spraying with fungicides, e.g. maneb, can control both diseases.

The major pests of snake gourd are leaf beetles (*Aulacophora vinula*, *Copa occidentalis* and *Lagria villosa*) and root knot nematodes (*Meloidogyne*).

Harvesting Snake gourds are picked 12–20 days after fruit set. The fruits should be harvested when they are about 30–60 cm long, green and tender. For seed production fruits are harvested when they are fully ripe and have attained full size; only straight fruits with perfect form are selected.

Yield Single snake gourd fruits weigh 0.5–1 kg. Per plant 6–10 fruits can be harvested from traditional cultivars, and up to 50 fruits from improved cultivars. Total yield varies from 8–10 t/ha.

Handling after harvest Snake gourds are very succulent and do not keep well. They can be stored for 10–14 days at a temperature of 16–17°C at a relative humidity of 85–90%.

Genetic resources Germplasm collections of snake gourd are available in the Philippines

(NPGRL-IPB, Los Baños), India (Kerala Agricultural University, Trichur, Kerala), Nigeria (NACGRAB, Ibadan), Russia (the Vavilov Institute of Plant Industries, Petersburg) and the United States (Department of Horticultural Sciences, Cornell University, New York).

Breeding Priority in breeding should be given to disease resistance and a high female to male flower ratio.

Prospects *Trichosanthes* will remain a minor vegetable crop in South-East Asia. Adequate investigation of the wild species might reveal desirable characteristics of interest to improve snake gourd or lead to domestication of other species with edible parts.

Literature |**1**| Bates, D.M., Robinson, R.W. & Jeffrey, C. (Editors), 1990. Biology and utilization of the Cucurbitaceae. Comstock, Cornell University Press, Syracuse, New York, United States. 485 pp. |**2**| Butani, D.K. & Verma, S., 1977. Pests of vegetables and their control. Chapter 11(3). Cucurbits. Indian Agricultural Research Institute (IARI), New Delhi, India. pp. 37–41. |**3**| Deshpande, A.A., Bankapur, V.M. & Venkatasubbaiah, K.A., 1980. Studies on floral biology of snake gourd (Trichosanthes anguina L.) and ash gourd (Benincasa hispida (Thunb.) Cogn.). Mysore Journal of Agricultural Science 14: 8–10. |**4**| Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 346–349. |**5**| Keraudren-Aymonin, M., 1975. Cucurbitacées. Trichosanthes. In: Flore du Cambodge, du Laos et du Vietnam [Flora of Cambodia, Laos and Vietnam]. Vol. 15. Muséum National d'Histoire Naturelle, Laboratoire de Phanérogamie, Paris, France. pp. 75–92. |**6**| Seshadri, V.S., 1986. Cucurbits. In: Bose, T.K. & Som, M.G. (Editors): Vegetable crops in India. Naya Prokash Press, Calcutta, India. pp. 91–164.

B.H. Gildemacher,
G.J. Jansen & K. Chayamarit

Vigna unguiculata (L.) Walp. cv. group Sesquipedalis

Repert. bot. syst. 1: 779 (1843). Cv. group Sesquipedalis: Westphal. Pulses in Ethiopia, their taxonomy and agricultural significance. p. 227 (1974).

LEGUMINOSAE

$2n = 22$

Synonyms *Dolichos sesquipedalis* L. (1763), *Vigna sesquipedalis* (L.) Fruhw. (1898), *V. sinensis* (L.) Hassk. ssp. *sesquipedalis* (L.) van Eseltine (1931), *V. unguiculata* (L.) Walp. ssp. *sesquipedalis* (L.) Verdc. (1970).

Vernacular names Yard-long bean, long bean, asparagus bean, snake bean (En). Dolique asperge, haricot kilomètre (Fr). Indonesia: kacang panjang, kacang usus, kacang belut. Malaysia: kacang panjang, kacang belut, kacang perut ayam. Philippines: sitao (Tagalog), hamtak (Bisaya), utong (Ilocano). Cambodia: sândaèk troeung. Thailand: tua fak yaow. Vietnam: d[aaj]u d[uwj]a, d[aaj]u gi[ar]i [as]o.

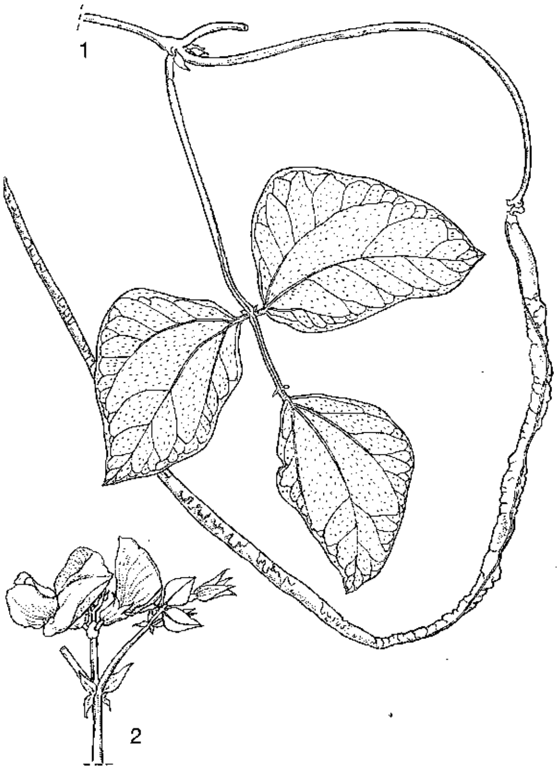
Origin and geographic distribution Yard-long bean very probably originated in East or South-East Asia, possibly from southern China in view of the large genetic diversity in this area. It is one of the top 10 vegetables in importance in all South-East Asian countries, Taiwan, southern China and Bangladesh. Yard-long bean is of much less importance in India and the Pacific. In the Philippines its importance is decreasing in favour of 'bush sitao', a crossing between yard-long bean and cowpea (cv. group Unguiculata), probably because 'bush sitao' does not need trellis and is less susceptible to wind damage. Yard-long bean spread with emigrants from South-East Asia to many countries in other tropical areas, where it is cultivated as a minor vegetable. It is quite popular in the Caribbean area and is produced as a summer crop in southern California. It is grown as a specialty greenhouse crop in the Netherlands.

Uses The succulent young pods of yard-long bean are used as a cooked vegetable, mostly combined with rice as the main dish. There are many preparation methods with various spices. Yard-long bean is an important ingredient of many vegetable soups. In Indonesia the consumption of fresh young pods in salads (lalab) is very popular. The consumption of mature dry seed as pulse comparable with cowpea (other cv. groups of *V. unguiculata*) is possible but unusual. The consumption of shoots and young leaves as leafy vegetable is popular in Indonesia and elsewhere.

Production and international trade Reliable statistics on yard-long bean are scarce because most of the crop is grown for home consumption; moreover, in statistics they are often combined with other leguminous vegetables. They are not included in FAO statistics. The area annually cultivated with yard-long bean in Indonesia (1988) is 97 000 ha, production 281 000 t. In Thailand (1988) about 10 000 ha of yard-long bean are grown, yielding 75 000 t. Yard-long bean is an important market vegetable in all South-East Asian countries where it is extensively grown in home gardens, on dikes around paddy fields and in fields in sole or mixed intercropping. It is a typical smallholder crop. Although yard-long bean is one of the most common vegetables on local markets, the quantity exported is insignificant.

Properties The composition per 100 g edible portion (pods) is: water 89 g, protein 3.0 g, fat 0.5 g, carbohydrates 5.2 g, fibre 1.3 g, ash 0.6 g, Ca 64 mg, P 54 mg, Fe 1.3 mg, vitamin A 167 IU, vitamin B_1 0.07 mg, vitamin C 28.0 mg. The energy value is 125 kJ/100 g. The rather high nutritional value, combined with the high level of intake, make yard-long bean a very important vegetable in the diet of South-East Asian people. The nutritional composition of yard-long bean is roughly comparable with French bean (*Phaseolus vulgaris* L.). The composition of the leaves is comparable with leafy vegetables like amaranth. The 1000-seed weight varies from 150–250 g.

Description A climbing, nearly glabrous annual, 2–4 m long, with well developed root system. Stems twining, more or less square, slightly ribbed, with nodes usually violet. Stipules prominent, ovate, appendaged. Leaves alternate, trifoliolate, with petiole 5–25 cm long; first two leaflets opposite, asymmetrical, top leaflet symmetrical, ovate, sometimes shallowly lobed, (6.5–)7–13.5 (–19.5) cm × (3.5–)4–9.5(–17) cm. Inflorescence an axillary raceme with several yellowish or pale-blue flowers clustered near the top; peduncle (4–)10–17(–32) cm long; rachis contracted, tuberculate; fertile flowers attached to a tubercle carrying abortive flowers, leaving gland-like tissue after being shed; bract 1 per flower, early deciduous; pedicel short; bracteoles 2, deciduous, obovate, 3–5 mm long; calyx campanulate, lobes 5–7 mm long; corolla with erect or spreading standard, 2–3 cm long, hood-shaped when older, wings 22 mm × 12 mm, keel boat-shaped, 21 mm × 12 mm; stamens diadelphous (9 + 1); ovary with 12–21 ovules. Pod pendent, 30–120 cm long, more or less inflated and flabby when young, constricted when mature, 10–30-seeded. Seed elongated, more or less cylindrical to rounded, variable in size and colour, usually 8–12 mm long, reddish-brown or black with a white hilum. Seedling with epigeal germination.



Vigna unguiculata (L.) Walp. cv. group Sesquipedalis – 1, fruiting shoot; 2, inflorescence.

Growth and development Yard-long bean seeds sown in moist earth of over 22°C germinate in 3–5 days. After germination, growth is very fast. Flowering starts in the 5th week after sowing and the harvest of young pods starts 2 weeks later. The degree of cross-pollination by insects is low in dry climates but may amount to 40% in locations with high relative air humidity. Depending on the crop health and intensity of harvesting, senescence starts $1^1/_2$–2 months after sowing and the plant dies after 3–4 months.

Other botanical information The typical feature of cv. group Sesquipedalis is the long, slack, pendent pod, which requires a climbing growth habit; the dry seeds are rarely consumed. It should not be confused with the 'catjang cowpea' which belongs to the cv. group Biflora, characterized by erect or ascending, short (10–15 cm), firm and succulent pods, not inflated when young, with plant habit erect or spreading, although semi-viny and climbing cultivars needing staking also occur. Not only the young pods and young seeds but also the mature dry seeds of cv. group Biflora are harvested and consumed like normal cowpea (cv. group Unguiculata). The so-called 'bush sitao' has become a popular vegetable in the Philippines. This cross between cowpea and yard-long bean has fleshy pods, 15–30 cm long, borne in pairs at the end of long peduncles arising above the canopy. It is a type of vegetable cowpea which

may also be included in cv. group Biflora.
In Malaysia, comparison of yard-long bean and vegetable cowpea types showed that staked yard-long bean was more productive (18–25 t/ha in 14 weeks) than the bush types (3–4 t/ha in 11 weeks) and the pods were more tender and palatable. Advantages of the short stiff pods of vegetable cowpea are the easier handling and packing for supermarkets compared to yard-long bean.
There are many landraces or cultivars within cv. group Sesquipedalis, mainly distinguishable by the characteristics of the young pods in the harvest stage. Other important cultivar features are: growth vigour and colour of the leaves, flowers and seed. A well known Indonesian cultivar is 'Usus Hijau' with dark green pods 60–80 cm long, succulent and regularly shaped, tolerant to podborer, anthracnose and witches' broom virus. Several cultivars derived from local landraces or farmers' selections are offered by private seed companies in the various countries.

Ecology Yard-long bean cultivars are daylength neutral or they may show a slight short-day reaction. They perform best under full sunlight but tolerate some shade. Day temperatures between 25–35°C and night temperatures not below 15°C are required, which means that cultivation is restricted to low and medium elevations. At elevations above 700 m growth is retarded. In fact French bean and yard-long bean are more or less complementary in this respect, the former being cultivated mainly at higher altitudes and in the lowlands during the cool season. However, there is a certain overlap; at medium elevations in Java and in the lowlands in Thailand and Vietnam both species may be found in the same field.
Yard-long bean performs well under humid conditions since it is not very susceptible to fungal diseases. The water requirement of the full grown crop is high, 6–8 mm per day. Cultivation in the dry season with ample irrigation is practised, as well as cultivation during the rainy season, provided that the drainage is adequate. Sowing during the rainy season may lead to damage to the emerging or young plants. The crop performs reasonably well on wet soils but an abrupt period of waterlogging causes serious damage and yield reduction. All soil types from light sandy or latosol to heavy clay are used, with a pH of 5.5–7.5. It is tolerant of slightly acid soil.

Propagation and planting Many farmers use the seed harvested from a previous crop. At the end of the harvest period they merely leave a sufficient number of pods to ripen. The dry seeds, which show no dormancy, are sown directly in hills (pockets) of 2–4 seeds. Cultivation is usually on raised beds for good drainage and easy surface irrigation and for easy staking and harvest. A common system consists of beds 1.2–1.5 m wide with double rows at 60–90 cm and 20–40 cm between the hills, leading to a density of 40 000–60 000 hills/ha. For sole cropping the amount of seed needed is 15–40 kg/ha. When planted on dikes and open spaces in other crops, the hills may be spaced the same distance (20–40 cm).
Earthing-up the young plants protects the shallow root system and gives some support to the seedlings. Some farmers apply a mulch of rice straw, but this is not a common practice.

Husbandry Yard-long bean has the same fertilizer requirements as the better known French bean. The recommendation for Indonesia is to apply 5–10 t/ha of farmyard manure during soil preparation, together with 50 kg/ha of urea, 50 kg/ha of KCl and 100 kg/ha of triple superphosphate.
Stakes 200–250 cm long are inserted near the seed stations before sowing or during the first two weeks after emergence (before the plants have reached a height of 30 cm). The method of staking varies, depending on the custom of the area, and is sometimes combined with ropes or wire. A cheap method of staking is to sow yard-long bean besides the stems of maize before or just after the cobs are harvested. Weeding by superficial hand hoeing is only needed during the first month. Once the crop is fully grown it outcompetes weeds. Three weeks after emergence a top dressing of 50 kg/ha urea is given, applied around the hills. The plants have to rely on their own N production for additional nitrogen. Seed is sometimes inoculated with *Rhizobium*, but this is not necessary on land previously used for leguminous vegetables. On fertile soils fertilization should be reduced, because if growth is too luxuriant pod set will be poor and the crop will be very susceptible to diseases and pests.

Diseases and pests The most damaging diseases are rust (*Uromyces vignae*), mildew (*Erysiphe polygoni*) and viruses such as cowpea aphid-borne mosaic virus and cowpea witches' broom virus. Control of the virus vectors (aphids, whiteflies, beetles and leafhoppers) and the removal of infected plants will help to keep virus diseases under control. Also common are *Cercospora* leaf-spot and anthracnose (*Colletotrichum lindemuthianum*), whereas bacterial blight (*Pseudomonas* *phaseoli*) is rarely a problem. The fungal diseases are more troublesome during the rainy season, whereas the insect pests, mites and virus diseases cause more damage during the dry season. For the control of virus diseases, fungal diseases (anthracnose) and bacterial diseases (*Pseudomonas*), it is very important to use healthy seed. No resistant cultivars are known.

The bean shoot fly *Ophiomyia phaseoli* is a common pest. The larvae tunnel in the leaves and stems. Severely attacked young plants will die and older plants will suffer from hampered growth and serious yield reduction. Another common pest is the bean pod fly *Melanogromyza sojae*. The larvae damage the petioles and young pods. Control involves protecting the seed with a systemic insecticide, e.g. carbofuran at sowing or applied as a solution to the emerging plantlets in the planting holes. During an attack, spraying with insecticides is recommended. Plant debris and affected plants must be burned. Pod-borers *Etiella zinckenella* and *Maruca testulalis* sometimes cause damage and may be controlled by chemical spraying. Yard-long bean is very attractive to aphids (*Myzus persicae*, *Aphis gossypii*), green stink bug (*Nezara viridula*) and red spider mite (*Tetranychus* spp.). Greasy cutworms (*Agrotis ipsilon*) often cause damage just after emergence. Sometimes thrips may cause damage. Chemical control of insects is common practice, often as a weekly routine, by spraying with a mixture of pesticides. Because of the risks for the farmer and the consumer, these sprayings must be reduced to the strict minimum.

Harvesting The first picking of young pods in the desirable stage takes place 6–7 weeks after planting. The best harvest stage depends on the cultivar and the market requirements. Normally the pods are picked when the outline of the seeds is just visible on the outside of the pod. Picking must be meticulous, because pods which are passed over until the next harvest will become tough and discoloured, with swollen seed which exhaust the plant. Successive harvests take place at least once a week (for a better tuned grading, twice a week) during 4–8 weeks.

Yield A total yield of 15 t/ha is considered satisfactory, but yields as high as 30 t/ha have been reported. In 1988, the average yield in Indonesia was 2.9 t/ha, in Thailand 7.2 t/ha. An indication of the potential yield is offered by the results of greenhouse cultivation in the Netherlands: growers obtain up to 8 kg/m^2 of marketable pods in a summer growing season of 4 months.

Handling after harvest The harvested beans are tied in bundles of 20–40 pods and packed in baskets or crates for transport to the market. Yard-long bean is less susceptible to loss of weight by transpiration and to transport damage than most other vegetables. In cool store (8°C) they will keep for 4 weeks.

Genetic resources Small collections of yard-long bean are present at the Asian Vegetable Research and Development Center (AVRDC), Taiwan, the Lembang Horticultural Research Institute (LEHRI), Indonesia, the Malaysian Agricultural Research and Development Institute (MARDI), Malaysia, and the Institute of Plant Breeding at Los Baños, the Philippines. The Institute for Vegetable Research at Beijing, China, has an interesting collection. Yard-long bean makes up a small part of the cowpea collection of the International Institute of Tropical Agriculture (IITA), Nigeria. Since commercial cultivars are on the rise, the huge diversity of yard-long bean landraces is in danger of genetic erosion.

Breeding Crop improvement has been done by some national research institutes and seed companies through selection and purification of landraces. Important selection criteria are yield capacity and market quality. Yield is strongly correlated with pod length and the number of pods per plant. In Malaysia, selections from landraces and line selection in crosses between local cultivars resulted in improved cultivars such as 'Sabah Black' with a yield potential of 25 t/ha. More breeding work using hybridization with other cv. groups of *V. unguiculata* showing valuable resistances should be started. Resistance to bean flies would be most welcome but seems difficult to achieve. Resistance to fungus and virus diseases might possibly be found.

Prospects Yard-long bean will remain one of the leading vegetables in South-East Asia. It may expand further to other tropical areas. It is possible that types with short stiff pods or the 'bush sitao' (cv. group Biflora) become more important because of easier handling. More emphasis should be put on control of diseases and pests without chemicals.

Literature |1| Haryono Semangun, 1989. Penyakit-penyakit tanaman hortikultura di Indonesia [Diseases of horticultural crops in Indonesia]. Gadjah Mada University Press, Yogyakarta, Indonesia. pp. 80–88. |2| Heij, G., 1989. Research experiences with yardlong bean in glasshouses in the Netherlands. Acta Horticulturae 242: 305–311. |3| Herklots, G.A.C., 1972.

Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 260–267. |4| Knott, J.E. & Deanon Jr, J.R. (Editors), 1967. Vegetable production in South-East Asia. University of the Philippines Press, Los Baños, the Philippines. pp. 66–96. |5| Mak, C., 1987. Comparative performance of vegetable cowpea and long bean. Malaysian Applied Biology 16(1): 323–325. |6| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 435–439. |7| Subhan, Sudjoko, Suwandi & Zainal Abidin (Editors), 1989. Bercocok tanam sayuran dataran rendah [Growing lowland vegetables]. Lembang Horticultural Research Institute (LEHRI), Bandung, Indonesia. Chapter 5, pp. 1–6. |8| Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. pp. 296–299.

G.J.H. Grubben

Zizania latifolia (Griseb.) Turcz. ex Stapf

Kew Bulletin 1909: 385–390 (1909).

GRAMINEAE

$2n = 30, 34$

Synonyms *Limnochloa caduciflora* Turcz. ex Trinius (1840), *Hydropyrum latifolium* Griseb. (1853), *Zizania caduciflora* (Trinius) Handel-Mazzetti (1936).

Vernacular names Manchurian wild rice, Manchurian water rice (En). Riz sauvage de Mandchourie (Fr). Thailand: nomai-nam (Bangkok), kapek (southern). Vietnam: c[ur] ni[eex]ng, ni[ee]ng ni[eex]ng, l[us]a mi[ee]u.

Origin and geographic distribution *Z. latifolia* is indigenous in north-eastern India, Burma, China, Japan, and in parts of eastern Siberia and the Russian Far East. Primarily used as a cereal in ancient times, its evolution and cultivation as a stem vegetable in China dates back at least to the 10th Century. It is now rather widespread in cultivation in eastern and south-eastern Asia (China, Korea, Japan, Taiwan, Indo-China, Thailand, Burma, Malaysia). In Indonesia it is cultivated locally by Chinese people. It has been introduced in Europe, New Zealand, and North America as well.

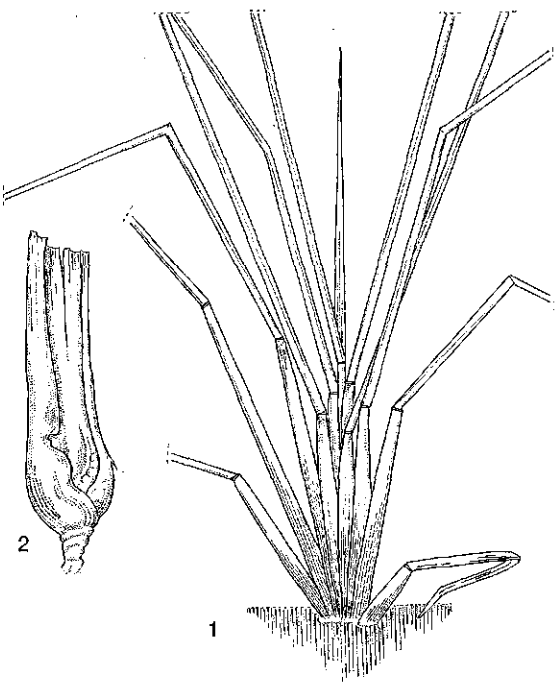
Uses *Z. latifolia* is cultivated for its swollen culm ('gau sun' in Cantonese), which is the result of hypertrophy caused by the smut fungus, *Ustilago esculenta*. It is probably the only product of a plant host and a fungal parasite eaten as a vegetable. Modes of preparation of the gall-like structure are similar to those for bamboo shoots. The firm, outer green layer is removed so that the softer, white inner portion remains. This is parboiled before further cooking or frying with meat and other vegetables, or canned in brine.

Grains of *Z. latifolia* have been used for food, sometimes in the form of flour. The culms, rhizomes and grains are prescribed during fevers for their cooling, diuretic, and thirst-relieving properties. The ash of the rhizomes mixed with white of egg is an ointment for burns. In Europe the plants have been used for forage and to make paper. In Japan the teliospores of the smut fungus, mixed with oil, are used to darken and thicken eyebrows and hair.

Production and international trade Manchurian wild rice is mainly grown on a small scale for domestic consumption and local markets. No production statistics are available.

Properties The swollen, infected culms contain per 100 g edible portion: water 78.5 g, protein 1.7 g, carbohydrates 4.7 g, cellulose 1.6 g, ash 0.5 g, Ca 21 mg, P 80 mg, Fe 1.2 mg, vitamin C 2.0 mg. The energy value is 109 kJ/100 g.

Botany Aquatic perennial tillering grass with strongly developed rhizomes and stolons, up to 3 m long. Mature rhizome unbranched, prostrate and nodose, green; apex and nodes solid, internodes hollow and divided into chambers by transverse membranous septa; mean external diameter 2 cm. Culm firm, erect, glabrous, filled with spongy pith and partitioned in the lower part, initially enclosed by the leaves but becoming exposed as the lower leaves die; apex solid, 0.6 cm long, consisting of 1–3 internodes; remainder of the culm consisting of 3 or more hollow internodes, each about 6 cm long; each node of the mature culm may give rise to a lateral bud which will develop into a shoot. Leaf-sheath loose, ribbed, glabrous; ligule 2.5 cm, top rounded and bifid; leaf-blade firm, narrowly linear-lanceolate, 50–100 cm × 2–3 cm, long-acuminate, scaberulous on both sides with very rough margins; midrib stout. Inflorescence a panicle, 40–60 cm long, narrowly pyramidal; branches ascending, arranged in pseudowhorls, with a tuft of long white hairs in the axils; male spikelets on the lower part of the panicle, lanceolate, 8–12 mm long, usually purplish, acute or short-awned; stamens 6; female spikelets on the upper part, pale green, linear, 15–25 mm; lemma oblong, acuminate, very scabrid; awns erect, 2–3 mm long, scabrous. Cary-



Zizania latifolia (Griseb.) Turcz. ex Stapf - 1, habit; 2, swollen culm base.

opsis linear-oblongoid, 5 mm × 1 mm.

Under the stimulus of *Ustilago esculenta* (enhanced production of auxins and cytokinins), the apical 3 or 4 internodes of the immature culm swell to produce a conical to fusiform, succulent, rather compact, fleshy gall, 5–10 cm × 2–4 cm, which is used as a vegetable. It consists for the greater part of host tissue and a comparatively small amount of mycelium of the fungus. Parasitized plants do not flower. The fungus survives in the rhizome and culm. *U. esculenta* is not known in other host species; it is a hardy fungus withstanding 15°C of frost. Flowering plants sometimes occur if produced on rhizomes not penetrated by the systemic mycelium.

Several cultivated forms are distinguished in East Asia mainly based on size, colour and texture of the galls.

Ecology The natural habitat of *Z. latifolia* includes borders of lakes, still-water bays and slow-running streams. It seems tolerant of a wide range of climatic and soil conditions.

Agronomy *Z. latifolia* is propagated vegetatively by planting rhizome parts with 1–3 stalks or by cuttings of immature culms consisting of 3–6 internodes. The smut fungus is usually present in these planting materials. The field should be flooded with a layer of water approximately 10–20 cm deep. Land preparation is very similar to that of rice fields. Organic fertilizer should be incorporated in the soil. On account of the strong tillering, *Z. latifolia* is planted at moderate densities ranging from 10 000–30 000/ha. Additional applications of fertilizer are carried out at intervals of about one month.

The major pests of Manchurian wild rice are similar to those of ordinary rice (*Oryza sativa* L.): the green leaf hopper (*Nephotettix bipunctatus*), the brown plant hopper (*Nilaparvata lugens*), paddy army worm (*Mythimna separata*) and paddy swarming caterpillar (*Spodoptera mauritia*).

Galls start to appear about 4–5 months after planting and are ready for harvest 1–2 weeks later. Subsequent harvests can be made at intervals of 1–2 weeks. Per tuft about 20–30 galls can be harvested per season. Galls are sized 5–10 cm × 2–4 cm, and weigh approximately 25–65 g. Harvesting is done manually and the galls are tied together by the leaf-sheath portion for transport to the market . The inner white core is also sold in cans and fresh-frozen in East Asia. The leaves can be harvested year-round for forage.

Genetic resources and breeding There are no known germplasm collections or breeding programmes. Near relatives of *Z. latifolia* are the American wild rices *Z. aquatica* L. and *Z. palustris* L., both annual species without rhizome.

Prospects More research is needed on the relationship between plant host and fungal strains. Processing techniques should be improved.

Literature |1| Petelot, A., 1954. Les plantes médicinales du Cambodge, du Laos et du Vietnam [Medicinal plants of Cambodia, Laos and Vietnam]. Vol. 3. Archives des Recherches Agronomiques et Pastorales au Vietnam No 22. pp. 294–295. |2| Pham Sy Lang & Dao Ngoc Dang, 1975. Cay cu nieng lam thuc an gia suc o vung dong chiem Binh Luc – Nam Ha [Zizania latifolia as a fodder crop at Nam Ha]. Khoa hoc va ky thuat nong nghiep [Science et Technologie Agricole] 5: 346–349. |3| Terrell, E.E. & Batra, L.R., 1982. Zizania latifolia and Ustilago esculenta, a grass–fungus association. Economic Botany 36(3): 274–285. |4| Thrower, L.B. & Yuk-Sim Chan, 1980. Gau sun: a cultivated host–parasite combination from China. Economic Botany 34(1): 20–26.

Nguyen Tien Hiep

3 Minor vegetables

Acalypha caturus Blume

EUPHORBIACEAE

Vernacular names Indonesia: hanjawan (West Java), goprak (Java), kalangkongan (Madura), kayu in cios (Sulawesi). Philippines: malasapsap (Tagalog), ambugtunong (Bisaya), migtanong (Bicol).

Distribution Indonesia (Sumatra, Java, Sulawesi, the Moluccas), Borneo and the Philippines. Possibly also in New Guinea.

Uses In the Minahasa (Sulawesi) cooked leaves are eaten.

Observations Shrub or small dioecious tree, 5–14 m tall. Leaves broadly ovate, cordate or triangular, 7.5–27 cm × 3–22 cm. In mixed or young forest and in plantations of tree crops like coffee, up to 1400 m altitude.

Selected sources 3, 4, 7, 44.

Aganope heptaphylla (L.) Polhill

LEGUMINOSAE

Synonyms *Derris heptaphylla* (L.) Merrill.

Vernacular names Indonesia: tali berkumpul, wali ahuhun (the Moluccas). Philippines: asi-asimanan (Tagalog), balay-lamok (Ilocano), baliotos (Bisaya).

Distribution From Sri Lanka, India and Burma east to southern China and south to the Philippines and New Guinea.

Uses Young leaves are eaten raw or cooked.

Observations Climbing or scrambling shrub, 3–15 m long. Leaves imparipinnately compound with 5–7 leaflets; leaflets elliptical or oblong-elliptical, 3–20 cm × 1.4–13 cm, coriaceous. In mangrove swamps, banks of littoral creeks, estuaries and associated forests up to 30 m altitude.

Selected sources 7, 44, 72, 92.

Allium schoenoprasum L.

LILIACEAE

Vernacular names Chives (En). Ciboulette, civette (Fr). Cambodia: kukiiw. Laos: hoom pèèn. Thailand: kuichai-farang, kuichai-baiklom (central), hom-paen (northern).

Distribution Wild throughout the northern hemisphere. Cultivated worldwide but mostly in temperate countries.

Uses Leaves are used in salads and for flavouring. It is also used as an ornamental.

Observations Perennial, very variable herb, 15–50 cm tall. Leaves narrow, tubular, terete, 10–50 cm × 1–7 mm. Bulbs gregarious, ovoid-oblongoid, 1–3 cm long, forming few to many lateral bulbs; in cultivated plants all bulbs inconspicuous. Flowers usually purple, in terminal subspherical heads without bulbils. It can be cultivated in the tropics at higher altitudes on a wide range of soils. Propagation is by division or by seed. In Thailand it is grown to a small extent commercially and for home consumption. World area of commercial production is about 1000 ha. Sometimes confused with *Allium chinense* G. Don.

Selected sources 16, 30, 73, 74, 87.

Allmania nodiflora (L.) R. Br. ex Wight

AMARANTHACEAE

Synonyms *Celosia nodiflora* L., *Chamissoa nodiflora* (L.) Mart., *Allmania pyramidalis* Koord.

Distribution Tropical Asia, from India to the Philippines, including western Malesia (e.g. throughout Indonesia).

Uses Young plant parts are edible, being prepared like spinach.

Observations Annual herb, up to 80 cm tall with linear-spathulate, rather fleshy leaves, 1–6 cm × 0.5–2.5 cm, dull green with purple margins, sometimes short hairy below. Flowers bisexual, in initially globose heads (later more elongate) of 1–2 cm diameter, pale green or purplish-green. Fruit an utricle, ellipsoid, 3.5 mm long, containing a glossy black seed with a basal, bilobed, pale pink or brown aril. Locally abundant as a weed on light, especially sandy soils, sandy shores, fields, roadsides and dunes, up to 100 m altitude. Propagation is by seed, but it is not cultivated. From India it is reported that it is a promising species for leaf protein production.

Selected sources 6, 7, 10, 85, 91.

Alpinia regia R.M. Smith

ZINGIBERACEAE

Synonyms *Languas regia* Burkill.

Vernacular names Indonesia: galoba gardamu (Ambon), manoa (Ternate).

Distribution Indonesia (the Moluccas).

Uses Flowers are eaten cooked. Leaves are used to pack cooked rice.

Observations Robust herb, up to 8 m tall. Leaves very large, up to 2.35 m × 0.45 m, slightly pubescent below. Flowers white, tubular, labellum oblong, 2 cm × 0.8 cm. The species is rare and resembles *Alpinia novae-hiberniae* Burtt & Smith from Papua New Guinea, but all its parts are larger.

Selected sources 44, 83.

Alternanthera philoxeroides (Mart.) Griseb.

AMARANTHACEAE

Synonyms *Ternanthera philoxeroides* (Mart.) Moq.

Vernacular names Alligator weed (En). Indonesia: tolod, krokot (Java). Thailand: phakpetnam.

Distribution Originating from tropical America, but often cultivated as an aquatic in other tropical areas, and often naturalized, e.g. in Indonesia, China, United States.

Uses In Indonesia young tops are eaten raw or cooked. In China plants are cultivated for compost-making. In the United States the plant is cultivated as food for lobsters.

Observations Creeping or floating, perennial herb, 50–100 cm long. Stems fistular with 2 hairy grooves. Leaves oblong to oblong-obovate, 2.5–8 cm × 0.7–2.5 cm. In Indonesia seed is never produced and propagation is only vegetatively. It occurs wild in swampy or very humid localities up to 1300 m altitude. In some places it is a serious aquatic weed.

Selected sources 7, 57, 66, 85.

Amischotolype mollissima (Blume) Hassk.

COMMELINACEAE

Synonyms *Campelia mollissima* Blume, *Forrestia mollissima* (Blume) Koorders.

Vernacular names Indonesia: kerok batok (Java), gewor, celi badak (West Java). Laos: ʻüang dông. Vietnam: l[aa]m trai.

Distribution From India to Indo-China, Peninsular Malaysia, Indonesia (Java, Sumatra).

Uses Young shoots are cooked and eaten as vegetable in Indonesia.

Observations Very variable, ascending, succulent, robust, perennial herb, 0.5–8 m tall. Leaves sheathed; leaf-blade lanceolate, 12–48 cm × 3.5–12 cm, sometimes pubescent or with soft hairs along the margins. In shady, humid localities, from 50–1500 m altitude. Mainly based on the hairiness of the leaves, three forms are distinguished (considered by some to be different species).

Selected sources 7, 66.

Aniseia martinicensis (Jacq.) Choisy

CONVOLVULACEAE

Vernacular names Indonesia: bagiu serut (Jambi), karut (South Sumatra), m(w)anaring-i-lawanan (North Sulawesi), imerpur (Irian Jaya). Malaysia: ulam putih, lidah patong. Cambodia: voë ʻanndaat trâkuöt. Thailand: chingcho (Bangkok). Vietnam: b[if]m n[uw][ow]c.

Distribution Pantropical, including all South-East Asian countries.

Uses Leaves are used as a vegetable in Malaysia and Indonesia.

Observations Slender, creeping or climbing herb, up to 1.5 m long. Leaves oblong, 3.5–11 cm × 0.7–5 cm. Flowers white, singular or 2–3 together on a common peduncle. In humid to swampy places, at low altitudes, e.g. along rice fields.

Selected sources 7, 20, 91.

Aporosa microstachya (Tulasne) Muell. Arg.

EUPHORBIACEAE

Synonyms *Aporosa maingayi* Hook.f.; *Aporusa* Blume = orthographic variant of *Aporosa* Blume.

Vernacular names Malaysia: kangkong udang, tampong pacat. Thailand: krimkhao (peninsular).

Distribution Burma, Thailand and Malaysia (Peninsular and possibly Sarawak).

Uses Leaves are eaten as a vegetable. The wood is a timber of low quality.

Observations Small tree, up to 8 m tall, in evergreen forest up to 400 m altitude. Leaves chartaceous, smooth, markedly caudate-acuminate.

Selected sources 1, 2, 20.

Arctium lappa L.

COMPOSITAE

Synonyms *Lappa major* Gaertner.

Vernacular names Great burdock, edible burdock (En). Bardane, gouteron (Fr). Japan: (yama-) gobo. Indonesia: gobo. Vietnam: ng[uw]u b[af]ng.

Distribution Grows wild from Europe to China and Japan and has been introduced in America. Cultivated mainly in Japan but also in China, Vietnam, the Philippines, Indonesia and Hawaii.

Uses Popular vegetable in Japan. The rather fibrous roots are prepared in several ways and consumed raw or cooked; the cooked peeled petioles are also eaten. In China, Vietnam and Europe it is chiefly known as a medicinal plant and as a weed of disturbed, neglected places. The root contains an essential oil.

Observations Robust, biennial herb, up to 1.5 m tall when flowering. Rosette leaves heart-shaped, 40–50 cm × 15–20 cm, white and pubescent beneath; petiole 20–30 cm long, solid. The bracts of the flowerhead involucre characteristically end in a long hooked tip so that the whole head becomes a bur. Taproot up to 1.5 m long, but for consumption a length of 60–70 cm and a diameter of 2.5–3 cm are preferred. Great burdock needs a light fertile soil and tolerates a wide range of climates. In the tropics it can be cultivated at higher altitudes. Breeding programmes are being carried out in Japan. *A. minus* (Hill) Bernh. (lesser burdock) is closely related but less cultivated; it differs in its hollow petioles and smaller flowerheads. It probably hybridizes naturally with *A. lappa*.

Selected sources 9, 43, 46, 57, 80, 97.

Ardisia elliptica Thunberg

MYRSINACEAE

Synonyms *Ardisia littoralis* Andr.

Vernacular names Malaysia: rempenai, penar, mata pelandok. Philippines: katagpo (Tagalog), kolen (Ilocano), bahagion (Bisaya). Thailand: ramyai (southern), langphisa (eastern), thulangkasa.

Distribution From southern India to southern China, South-East Asia, tropical Australia and the Pacific, wild and occasionally cultivated.

Uses Young shoots are eaten raw or cooked. Leaves are used medicinally.

Observations Shrub or small tree, up to 10 m tall. Leaves obovate-oblong to oblong, 5–12.5 cm × 2.5–5 cm, entire, glandular dotted below, with prominent parallel lateral veins, coriaceous, pink when young. In lowland vegetation, often along coasts and tidal estuaries.

Selected sources 20, 42, 82.

Ardisia laevigata Blume

MYRSINACEAE

Vernacular names Indonesia: ki mangu (West Java), lempeni (Java), jambulan pante (North Sulawesi), rampasi (West Sumatra).

Distribution Indonesia and Peninsular Malaysia.

Uses Leaves are edible.

Observations Shrub to small tree up to 5 m tall. Leaves elliptical-oblong or subobovate, 10–22.5 cm × 6–10 cm, entire, reticulately veined, thinly coriaceous, pellucid-dotted throughout. In forest at 1400–2200 m altitude.

Selected sources 7, 44.

Argusia argentea (L.f.) H. Heine

BORAGINACEAE

Synonyms *Tournefortia argentea* L.f., *Messerschmidia argentea* (L.f.) Johnston.

Vernacular names Velvet leaf (En). Indonesia: babakoan (West Java), karpo (Ternate), moral babulu (Ambon). Philippines: kapal-kapal (Tagalog), salakapo (Ilocano), bukabuk (Bisaya). Vietnam: b[aj]c bi[eer]n, phong ba.

Distribution Around warmer parts of the Indian Ocean and the Pacific, wild and cultivated.

Uses Leaves have the taste of parsley and can be eaten raw. They are also dried and smoked like tobacco. In Vietnam the leaves are used as medicine against the venom of sea-snakes.

Observations Crooked tree or erect shrub, up to 10 m tall. Leaves alternate, obovate to lanceolate, 10–32 cm × 3–13 cm, fleshy, densely silvery hairy on both sides. Typical along sandy seashores.

Selected sources 7, 20, 27, 44, 57.

Artanema longifolium (L.) Vatke

SCROPHULARIACEAE

Synonyms *Artanema angustifolium* Benth., *A. sesamoides* Benth.

Vernacular names Malaysia: sesawi pasir. Thailand: phakmanpu, ya-khaina (central). Vietnam: v[uwf]ng d[aas]t.

Distribution Tropical Africa, and from India to Indo-China and throughout Malesia.

Uses Leaves are said to be edible.

Observations Erect herb, up to 1 m tall, with quadrangular to 4-winged stem. Leaves sessile, lanceolate, 3.5–16 cm × 1–3.5 cm, glabrous to scabrid. Flowers purple. In humid and swampy places, common along rice fields, up to 400 m altitude.

Selected sources 7, 20, 84, 85.

Barbarea verna (Miller) Ascherson

CRUCIFERAE

Synonyms *Barbarea praecox* (Smith) R. Br.

Vernacular names Winter cress, upland cress (En). Cresson de terre (Fr).

Distribution Wild and sometimes cultivated in western and south-western Europe, especially in France and Belgium. Introduced to Africa, America and Asia, e.g. in Malaysia it is cultivated to a small extent.

Uses Leaves are used as a salad and are spicy like garden cress.

Observations Biennial herb, up to 75 cm tall, with its radical leaves in a rosette. Leaves pinnately lobed, with 4 or more pairs of lobes and a larger terminal lobe. For good growth it needs cool temperate conditions and a moist soil. In the tropics it is only suitable for high altitudes. The related and in Europe similarly used species *B. vulgaris* R. Br. has been introduced in East Java, Indonesia.

Selected sources 7, 9, 20, 39, 57, 65.

Begonia L.

BEGONIACEAE

Major species and synonyms
- *Begonia hirtella* Link.
- *Begonia muricata* Blume, synonym: *B. tuberosa* Lamk.

Vernacular names
- *B. hirtella*: Bearded begonia (En). Indonesia: hariyang bulu (West Java).
- *B. muricata*: Indonesia: hariyang peucang (West Java), daun asam, tai bawi (Ambon). Vietnam: thu h[ar]i d[uw][owf]ng, chua khan.

Distribution *B. hirtella* is native to the West Indies, Brazil and Peru. In Malaysia and Indonesia it is an escape from cultivation. *B. muricata* is indigenous to Indonesia and is occasionally cultivated elsewhere.

Uses The sour leaves and stems are eaten raw or cooked in Indonesia. The plants are also used as ornamentals.

Observations Juicy herbs, up to 40 cm (*B. hirtella*) or 90 cm (*B. muricata*) tall. Leaf-blades obliquely ovate-cordate, 2.5 cm × 2–7 cm in *B. hirtella*, 4.5–17.5 cm × 4.5–13 cm in *B. muricata*, petioles short in *B. hirtella*, up to 25 cm long in *B. muricata*. Both species like humid, stony sites, but *B. muricata* grows at higher altitudes (1000–2000 m) than *B. hirtella* (up to 1300 m). In New Guinea and the Philippines several other *Begonia* species are eaten as a vegetable.

Selected sources 7, 11, 44.

Belosynapsis moluccana (L.) Fischer

COMMELINACEAE

Synonyms *Commelina moluccana* Roxb., *Cyanotis moluccana* (Roxb.) Merrill.

Vernacular names Indonesia: gewor, tali (in common with other Commelinaceae). Philippines: kuwan-kuwan-matug (Pint.-Sambali).

Distribution Native to the Moluccas, but occurs also in the Philippines, New Guinea, Borneo and Java.

Uses Leaves and stems are used as a vegetable in the highlands of New Guinea. The plant also provides a good fodder.

Observations Herb up to 30 cm tall, ascending from a decumbent base, branched. Leaf sheathing at base; leaf-blade ovate-oblong, 1–3.5 cm × 0.5–1 cm, ciliate. Flowers actinomorphic, blue, solitary, terminal; petals free. In humid places, e.g. in ravines, along small streams, at low and medium altitudes. In Papua New Guinea locally cultivated and propagated by cuttings.

Selected sources 7, 29, 60.

Brassica napus L.

CRUCIFERAE

Major taxa and synonyms

- Cv. group Colza. Synonyms: *B. napus* L. ssp. *napus*, *B. napus* L. var. *napus*, *B. napus* L. var. *arvensis* Thellung.
- Cv. group Rutabaga. Synonyms: *B. napus* L. ssp. *rapifera* Metzger, *B. napus* L. var. *napobrassica* (L.) Reichb., *B. oleracea* L. var. *napobrassica* L.

Vernacular names

- Cv. group Colza: Colza, rape (seed) (En). Colza, navette (Fr).
- Cv. group Rutabaga: Rutabaga, swede (En). Rutabaga, chounavet (Fr).

Distribution Only known from cultivation, but sometimes escaped to the wild, mainly in Europe. Occasionally cultivated elsewhere, including South-East Asia.

Uses

- Cv. group Colza: mainly cultivated for the oil of the seed, which is a valuable edible oil with many applications. Leaf-rich forms are also cultivated for their leaves, used as vegetable or as forage.
- Cv. group Rutabaga: mainly cultivated for its edible tubers, eaten cooked or used as forage.

Observations Annual or biennial herbs, up to 2 m tall. Cultivars of the Rutabaga group develop a thick, subglobose, underground tuber with yellowish to whitish flesh. Cultivars of the Colza group bear 4–12 or more, basal, lyrate-pinnatifid leaves; flowers yellow; fruit a silique, 5–10 cm long with a slender beak; seeds in one row, globose, 1.5–3 mm in diameter, blackish. Plants prefer a humid cool climate and will grow on any kind of soil. Propagation is by seed. Rotation with non-cruciferous crops is important to minimize diseases and pests.

Selected sources 5, 9, 39, 57, 66, 74, 81.

Broussonetia luzonica (Blanco) Bureau

MORACEAE

Synonyms *Allaeanthus luzonicus* Fernandez-Villar.

Vernacular names Philippines: himbaba-o, babayan (Tagalog), baeg (Ilocano), balong-kadios (Bisaya).

Distribution The Philippines (from northern Luzon to Mindanao).

Uses Flower spikes and leaves are eaten cooked. They are sold on local markets. A weak rope can be made from the bark.

Observations Tree up to 15 m tall. Leaves ovately oblong, 5–15 cm long, with pointed apex. Inflorescence with many small flowers on long spikes. In thickets and secondary forest up to 1100 m altitude.

Selected sources 13, 61, 86.

Cardiopteris Royle

CARDIOPTERIDACEAE

Major species and synonyms

- *Cardiopteris moluccana* Blume.
- *Cardiopteris quinqueloba* (Hassk.) Hassk., synonyms: *C. lobata* R. Br., *Peripterygium quinquelobum* Hassk.

Vernacular names

- *C. moluccana*: Indonesia: uge jabba (Ternate), uta lala (Ambon), mata-mata (Sulawesi). Philippines: tabolo (Bisaya), bangogan (Bicol), lila (Bukidnon). Papua New Guinea: gogomangeni (Wapi), kehunghe (Mekeo).
- *C. quinqueloba*: Indonesia: saburung, ruru-ruruan (Sudanese), angin-anginan (Javanese). Malaysia: gamba puteh. Laos: liinz lii, hviid. Thailand: khaosankhang (southern), phaktaentae. Vietnam: mai r[uf]a, t[if] d[uwj]c.

Distribution *C. quinqueloba* occurs from western Bangladesh and Assam to Burma, Thailand, Indo-China and Yunnan, Malaysia and Indonesia. *C. moluccana* occurs in Indonesia, the Philippines and New Guinea.

Uses Leaves have a cabbage taste and are eaten raw or cooked (slimy) as a vegetable. In Ternate a decoction of the stem of *C. moluccana* is also used medicinally against hepatitis.

Observations Climbing herbs with milky juice, up to 9 m long. Leaves spirally arranged, palmatinerved, long petiolate; in *C. quinqueloba* leaf-blade broadly ovate in outline, 3–5(–9)-lobed, membraneous, 4–17 cm × 3–16 cm; in *C. moluccana* leaf-blade entire, chartaceous, ovate-cordate, up to 24 cm × 22 cm. On the edge of forest and thickets and in open places such as limestone outcrops. Mostly at low elevations but sometimes up to 1500 m altitude.

Selected sources 44, 91.

Cassia obtusifolia L.

LEGUMINOSAE

Vernacular names Sicklepod (En). Indonesia: ketepeng. Malaysia: gelenggang sayor, gelenggang nasi. Philippines: balatong-aso (Tagalog), andadasi (Ilocano), baho-baho (Bisaya). Vietnam: d[aaj]u ma.

Distribution Pantropical. Probably native to tropical America.

Uses Leaves and young tops are eaten. Leaves and roots are also used medicinally against vomiting and stomachache.

Observations Annual or perennial, often bad-smelling herb or shrub, up to 2.5 m tall. Leaves compound with 3 pairs of leaflets; rachis 4–7 cm long; leaflets obovate, 1–6 cm × 0.5–3.9 cm. On roadsides, waste places and fallow fields up to 800 m altitude. Often confused with *C. tora* L. which has different anthers and seeds.

Selected sources 7, 20, 92.

Champereia manillana (Blume) Merrill

OPILIACEAE

Synonyms *Champereia griffithii* Planchon ex Kurz.

Vernacular names False olive (En). Indonesia: sayor garing (the Moluccas), cemperai. Malaysia: chemperai, belkan. Philippines: garimo, liyong-liyong (Tagalog), panalayapen (Ilocano). Thailand: phakwan, phak puem, sen.

Distribution Throughout South-East Asia, Andaman and Nicobar Islands and Taiwan.

Uses Young leaves and fruits are commonly sold on local markets and eaten as a vegetable. Leaves and roots are also used medicinally to cure ulcers, rheumatism, headache and stomachache.

Observations Gynodioecious shrub to small tree, 4–10 m tall. Leaves very variable in form and size, ovate, oblong or lanceolate, 4.5–25 cm × 1.5–11 cm. Inflorescence a panicle with greenish flowers. Fruit a drupe, ellipsoid, orange-red, 0.8–1.5 cm × 0.7–0.9 cm. In primary and secondary open evergreen forest and in dry monsoon forest, usually not above 900 m altitude. In Burma, Thailand and Indo-China the leaves can be confused with the poisonous leaves of *Urobotrya siamensis* Hiepko.

Selected sources 7, 84, 91.

Cichorium intybus L.

COMPOSITAE

Vernacular names Brussels chicory, witloof (En). Chicorée witloof (Fr). Vietnam: di[ees]p xo[aw]n.

Distribution Native to Europe, western Asia and Central Russia. Introduced (cultivated and wild), mainly in temperate regions.

Uses The bitter leaves are a favourite vegetable in Europe but not very well known in South-East Asia. A red-leaved variety is used in salads, also occasionally in South-East Asia. The root can serve as a substitute for coffee.

Observations Perennial herb with milky sap and a strong taproot, up to 1.5 m tall when flowering. Basal leaves in a radical rosette, oblong or oblong-spatulate, 10–37 cm × 2–11 cm. Green leaves can be eaten but usually it is grown for its blanched heads of rosette leaves: the 'witloof'. Cultivation is complicated; first a straight root has to be grown in a loose soil. After harvesting the whole plant, the leaves are cut off and next the roots are replanted and covered with soil or grown in the dark to allow the blanched leaf-heads to develop. When they are about 15 cm high they are harvested. Witloof is rare in tropical regions but adapted hybrids have potential for cultivation at higher altitudes. A red, non-blanched, Italian type with prominent white midribs ('radicchio rosso') is becoming more popular, in the tropics too. Cultivars of the Brussels chicory can be classified in cv. group Foliosum; those of the coffee chicory in cv. group Sativum.

Selected sources 7, 53, 57, 62, 65, 66.

Cissus javana DC.

VITACEAE

Synonyms *Cissus discolor* Blume, *Vitis discolor* (Blume) Dalz.

Vernacular names Indonesia: mirah (Java), beubeureuman (West Java), rabet dara (Madura). Philippines: mangangaria (Marinduque). Thailand: dattakua-thao (Bangkok), kham-daeng, lang-daeng (peninsular). Vietnam: h[oof] d[awf]ng hai m[af]u.

Distribution From India to southern China, including South-East Asia, wild and cultivated.

Uses The sour leaves and young shoots are eaten mixed with other vegetables. Also planted as an ornamental. Medicinally the leaves are used against stomachache.

Observations A twining shrub up to 15 m long, with bifid tendrils. Leaves distichous, petiolate, ovate to oblong to lanceolate with cordate or truncate base, 5.5–25 cm × 2.5–21 cm, above green with greyish-green blotches, beneath dark red, rarely green. In moderately shady localities up to 1200 m altitude.

Selected sources 7, 61, 66.

Cissus repens Lamk

VITACEAE

Synonyms *Vitis quadricornuta* Miquel, *V. repens* Wight & Arnott.

Vernacular names Indonesia: areuy hariang (West Java), sambung tulang (Bali), daun bisul (the Moluccas). Malaysia: lakum. Philippines: kalitkalit, ayo (Tagalog), manalitak (Bisaya), anupol (Bukidnon). Cambodia: voë sedaa. Laos: hôôb hééb, sômz puun. Thailand: thaokhan (southern). Vietnam: d[aa]y ch[if]a v[oo]i xanh, h[oof] d[awf]ng b[of], d[aa]y ph[aas]n.

Distribution From India to southern China, including South-East Asia.

Uses In Indonesia the sour leaves and shoots are eaten mixed with other vegetables. They are also used medicinally as poultices on swellings and against fever. Stems are used as rope and said to be strong enough to tether buffaloes.

Observations Climbing or creeping tendrilled herb up to 15 m long, often with tuberous roots. Leaves distichous, petioled, ovate or 3–5-angular or lobed, usually with deeply cordate base, 2.5–20 cm × 1–12 cm, green, sharply serrate. In moderately shady localities up to 1000 m altitude.

Selected sources 7, 13, 66.

Claoxylon longifolium (Blume) Endl. ex Hassk.

EUPHORBIACEAE

Vernacular names Indonesia: ketepuk, kuyam (Java), kileat (West Java). Malaysia: sayor salang. Philippines: kurong (Bisaya), bilid-bilid (Sulu). Thailand: phakwan-chang (southern). Vietnam: l[awj]c ma, b[oof] l[oos]t l[as] d[af]i.

Distribution From north-eastern India to Indo-China and throughout Malesia to New Guinea.

Uses Young leaves and shoots are eaten cooked. Leaves are used to wrap fish for roasting.

Observations Shrub or small tree up to 12 m tall. Leaves ovate to oblong, sometimes elliptical, 12–40 cm × 4–15 cm, apex ending in a rather long point, thin. In primary mixed forest, from 200–2000 m altitude. In Malaysia sometimes cultivated.

Selected sources 2, 3, 4, 7, 66, 86.

Cleistanthus sumatranus (Miquel) Muell. Arg.

EUPHORBIACEAE

Synonyms *Cleistanthus heterophyllus* Hook.f.

Vernacular names Indonesia: belimbing rawah (Lampung). Malaysia: keremak hutan. Cambodia: spüü tük. Thailand: fin-daeng (central).

Distribution Indonesia, Malaysia, the Philippines, Thailand, Indo-China and Hainan.

Uses Leaves are reported to be eaten.

Observations Tree, 5–14 m tall. Leaves very variable, usually ovate to oblong, 3.5–17 cm × 1–7.5 cm, 5–6 lateral veins on either side, acuminate at apex. In dry evergreen or deciduous forest up to 600 m altitude. The species much resembles the less common *C. gracilis* Hook.f.

Selected sources 2, 3, 4, 7, 20.

Commelina L.

COMMELINACEAE

Major species and synonyms
- *Commelina benghalensis* L.
- *Commelina paleata* Hassk.
- *Commelina paludosa* Blume, synonym: *C. obliqua* Ham.

Vernacular names
- *Commelina*: Dayflower (En). Indonesia: tali, gewor (in common with other Commelinaceae).
- *C. benghalensis*: Indonesia: kekupu (West Java), arewi (Minahasa). Malaysia: rumput mayam. Philippines: sabilau, alibangon (Tagalog), kulkul-lasi (Ilocano), kabilaw (Bisaya). Laos: kaab pii. Thailand: phakprap. Vietnam: d[aa][uf] ri[ee][uf], th[af]i l[af]i.
- *C. paleata*: Indonesia: brambangan (Java), moksor (Madura).
- *C. paludosa*: Indonesia: ki sepat (West Java). Vietnam: trai n[uw][ows]c, rau trai.

Distribution *Commelina* is a large genus, occurring worldwide in tropical and subtropical regions. *C. benghalensis* has an Old World origin, but is now a pantropical weed. *C. paleata* is only known from Indonesia. *C. paludosa* occurs from India to Indo-China, Malaysia and Indonesia.

Uses Leaves and young tops of *Commelina* (especially *C. benghalensis*) are occasionally steamed and eaten as vegetable in Indonesia. In the Philippines they are eaten cooked. *C. benghalensis* and *C. paleata* have medicinal value as well. Usually *Commelina* spp. are also useful forages.

Observations Slender, creeping and ascending branched herbs up to 1 m long. Leaves oblong to lanceolate with sheathing base, sessile or shortly petioled. Flowers ephemerous, zygomorphic, blue, in short branched cincinni enclosed in a green, folded, funnel-shaped bract. *C. benghalensis* and *C. paludosa* occur in humid to swampy places; *C. paleata* in dry to humid, but not swampy localities. *C. benghalensis* occurs up to 900 m, *C. paleata* up to 750 m and *C. paludosa* up to 2000 m altitude in the tropics.

Selected sources 7, 20, 44, 76, 85.

Crateva religiosa Forster f.

CAPPARACEAE

Synonyms *Crateva macrocarpa* Kurz.

Vernacular names Sacred barma (En). Indonesia: jaranan (Java), barunday (West Java), sihaluak (Sumatra). Malaysia: kepayan, kemantu hitam. Philippines: salingbobog (Tagalog), balailamok (Ilocano), banugan (Bisaya). Cambodia: tonliëm. Laos: kumz. Thailand: kum-bok, kum. Vietnam: b[us]n thi[ee]u.

Distribution From India throughout South-East Asia to Micronesia and Polynesia, wild and occasionally cultivated.

Uses Leaves are used as a vegetable in Indo-China and India. Fruits are edible; in West Borneo they serve as fish bait. In the Philippines several parts of the plant are used medicinally against a number of ailments.

Observations Tree, 5–15(–30) m tall. Leaves trifoliolate. Leaflets very variable, asymmetrically oblong to ovate, 8.5–27 cm × 3–10.5 cm, subsessile, thin-herbaceous. Fruit a berry, subglobular to subovoid, 6–15 cm × 5.5–9.5 cm, white. Often in periodically inundated forest, usually below 100 m altitude but occurring up to 700 m. In India and Polynesia often planted around temples.

Selected sources 13, 20, 27, 84, 91.

Cryptotaenia canadensis (L.) DC.

UMBELLIFERAE

Synonyms *Cryptotaenia japonica* Hassk.

Vernacular names Japanese honewort (En). Indonesia: mitsuba, salderi Jepang.

Distribution Native to Japan, China and north-eastern America. Introduced into South-East Asia and cultivated occasionally.

Uses The aromatic leaves are eaten, raw or cooked. They are used for flavouring soups and other dishes in the same way as celery leaves.

Observations Perennial, rhizomatous, erect herb, 20–125 cm tall. Leaves trifoliolate, the lowest ones largest with very long petioles; leaflets sessile, broadly ovate, obovate or oblique rhomboid, 2–12 cm × 1.5–8 cm, sharply biserrate-dentate. Easy to cultivate, also at low altitudes. Propagation by rhizome cuttings or by seed. The plant demands a humus-rich soil. Harvesting starts when plants are 20–25 cm tall.

Selected sources 7, 43, 66, 91.

Curcuma mangga Valeton & Van Zijp

ZINGIBERACEAE

Vernacular names Indonesia: temu lalab, temu mangga, kuning pari. Malaysia: temu pauh. Thailand: khamin-khao.

Distribution Cultivated in Indonesia, Malaysia and Thailand. Uncertain whether it occurs wild.

Uses Unlike most other Zingiberaceae, the main use of *C. mangga* is as a vegetable. Young tops of rhizomes and also young shoots are eaten, raw or cooked. Inflorescences are eaten cooked.

Observations Perennial, erect, rhizomatous-tuberous, tillering herb, 50–200 cm tall. Leaves elliptical-oblong or oblong-lanceolate, 15–95 cm × 5–20 cm. Inflorescences on a separate stem, sprouting laterally from the rhizome; spike cylindrical, 10–20 cm × 3.5–9 cm; flowers slender, ca. 4 cm long, white but with a yellow midlobe. Rhizomes are citrin-yellow within and have the smell of young mango fruits. It is propagated from pieces of the rhizome and needs a very fertile soil.

Selected sources 7, 20, 44, 45, 66, 88.

Cyanotis cristata (L.) D. Don

COMMELINACEAE

Synonyms *Commelina cristata* L.

Vernacular names Indonesia: petungan (Java), gewor, tali (both latter names in common with other Commelinaceae). Philippines: alikbangon (Tagalog), kulasing-akabaleg (Pangasinan).

Cambodia: smau slaab tiĕ. Laos: kaab pii. Thailand: ya-huaraknoi (northern). Vietnam: b[is]ch trai m[oof]ng.

Distribution Originating in tropical Asia and Africa, but is now a pantropical weed.

Uses Leaves and stems are used as a vegetable in West Java. The species is also useful as a forage.

Observations Erect or ascending, branched herb, up to 40 cm tall with sheathing leaves. Stem with a longitudinal row of hairs, juicy. Leaf-blade fleshy, oblong to lanceolate, up to 12 cm × 2.5 cm. Flowers actinomorphic, blue, closely arranged in curved biseriate cincinni; petals highly connate into a tube. Especially in dry, but also in humid regions, on roadsides, rocks or stones, up to 1000 m altitude.

Selected sources 7, 60, 66, 76, 85.

Cyclanthera pedata (L.) Schrader

CUCURBITACEAE

Vernacular names Wild cucumber, korilla, achoccha (En).

Distribution Native to Andean South America, but now only known in cultivation or as an escape from cultivation. Cultivated from Mexico to Peru and Ecuador and also occasionally in the Old World tropics (e.g. Malaysia, Nepal, Taiwan).

Uses Young fruits are eaten, raw or cooked. The seeds should be removed from the older fruits; the resulting seed cavity is suitable for stuffing with meat and spices. The taste is like cucumber. Young shoots and leaves are also edible.

Observations Annual, vigorous vine up to 5 m long. Leaves suborbicular in outline, ca. 17.5 cm × 20 cm, palmately 3–5-foliolate. Fruit a pepo, tapering, flattened, obliquely ovoid, up to 16 cm long, white-green, sometimes with soft spines, with a spongy, partly hollow seed cavity, filled with black-brown seeds. Wild cucumber is fairly tolerant of cold and is suitable for cultivation in tropical highlands up to 2000 m altitude. Planting distance is 90 cm × 90 cm. Plants have to be staked. The closely related *C. brachystachia* (Ser.) Cogn. (synonym *C. explodens* Naudin), originating from the same area, is also cultivated for its edible fruits.

Selected sources 12, 14, 17, 43, 57, 64, 96.

Cynanchum ovalifolium Wight

ASCLEPIADACEAE

Synonyms *Cynanchum javanicum* (Koorders) Bakh. v.d. Brink, *Marsdenia javanicum* (Koorders) Bakh. v.d. Brink.

Vernacular names Indonesia: sayor makan darat (the Moluccas). Malaysia: akar banoh jantan.

Distribution From the Indian subcontinent through Malesia to Australia.

Uses Leaves, which are very bitter, and young fruits are eaten in the Moluccas.

Observations Slender herbaceous vine with white latex. Leaf-blade ovate-oblong to lanceolate, 5–14 cm × 2–7 cm, discolorous; petiole 2–4 cm long, at nodes with small to large (1 cm long) stipule-like or leaf-like stipular structures. Fruit a fusiform-ovoid follicle, 7.5–10 cm × 3–3.5 cm. In brushwood, hedges and open places up to 1000 m altitude.

Selected sources 7, 35, 42.

Cynara L.

COMPOSITAE

Major species and synonyms

- *Cynara cardunculus* L.
- *Cynara scolymus* L., synonym: *C. cardunculus* L. ssp. *scolymus* (L.) Hegi.

Vernacular names

- *C. cardunculus*: Cardoon (En). Cardon (Fr). Vietnam: ba cai.
- *C. scolymus*: Artichoke (En). Artichaut (Fr). Vietnam: [as]c ti s[oo], hoa dira.

Distribution Cultivated since ancient times in the Mediterranean region where both species originated. *C. scolymus* is only known from cultivation, but *C. cardunculus* also occurs in the wild. Other areas of cultivation include South America, Central Asia, Japan, and occasionally in Vietnam, Papua New Guinea and Indonesia.

Uses The fleshy base (receptacle) of the not yet opened flowerhead and the thickened bases of the involucral bracts of artichoke are considered a delicacy, and are eaten raw or more usually cooked. The large tender petioles of artichoke can also be eaten but it is cardoon which is primarily cultivated for this purpose. Both plants are also decorative ornamentals. In Vietnam artichoke leaves are used as a medicine in case of retention of the urine or bile, kidney inflammation and rheumatism.

Observations Closely related, large, perennial, thistle-like herbs, up to 2 m (cardoon) or 1.5 m (artichoke) tall. Leaves irregularly pinnately lobed, 30–100 cm long, prominently spiny (cardoon) or hardly spiny (artichoke); petiole of cardoon is thickened. Flowerhead globose with many involucral bracts which enclose violet-blue florets; head of artichoke 4–8 cm in diameter, with enlarged and fleshy receptacle and involucral bracts broad and thickened at base, unarmed; heads of cardoon smaller and with spine-tipped involucral bracts. In not too humid conditions, cultivation in the tropics is possible at altitudes above 1500 m. Propagation is from seed or suckers (*C. scolymus*). Planting distance 1 m × 1 m. Requires very fertile soil.

Selected sources 7, 9, 43, 50, 57, 58, 65, 98.

Cyperus diffusus Vahl

CYPERACEAE

Vernacular names Indonesia: ilat (West Java). Malaysia: para-para, rumput bemban. Philippines: gumu-gumi (Tagalog), barsangabakin (Ilocano), baliw-baliw (Bicol), singao (Mindanao). Laos: f'uuk, haang kaa, phüü dông. Vietnam: l[as]c lan, c[os]i x[of]e.

Distribution From India to southern China and Taiwan, throughout South-East Asia, and in the Solomon Islands.

Uses In Indonesia young plants are eaten raw as vegetable, and in the Philippines roots are used as a medicine for diseased lips.

Observations Perennial, rhizomatous herb, up to 80 cm tall. Stem trigonous, often tufted. Leaves linear or linear-lanceolate, scabrous, 15–85 cm × 0.5–2 cm with 3 prominent main nerves. In humid, shady localities, below 800 m altitude.

Selected sources 7, 66, 91.

Cyrtandra decurrens De Vriese

GESNERIACEAE

Vernacular names Indonesia: daun laur, daun wawo (Ambon).

Distribution Indonesia (the Moluccas).

Uses Used as a leafy vegetable in the Moluccas.

Observations Herb, 30 cm tall with quadrangular, unbranched stem. Leaves opposite, long petiolate, obovate. In dark humid places. The species is hardly known. It is one of a group of closely allied species including *C. bracheia* B.L. Burtt, *C. erectipila* B.L. Burtt and *C. subgrandis* B.L. Burtt.

Selected sources 21, 44.

Dendrolobium umbellatum (L.) Benth.

LEGUMINOSAE

Synonyms *Desmodium umbellatum* (L.) DC.

Vernacular names Indonesia: daun buaya (the Moluccas), kanyere laut (West Java), balanak (Java). Malaysia: petai laut, dedulang. Philippines: kabay-kabay (Tagalog), huyat-bagio (Bisaya), matang-ureng (Bicol). Thailand: chamaep, khamin-nang (eastern). Vietnam: tr[af]ng q[ur]a t[as]n.

Distribution In the tropics and subtropics of the Old World (Africa, Australia, Asia, Pacific Islands).

Uses Leaves are eaten raw in the Moluccas and Malaysia. They are also used in traditional medicine.

Observations Very variable shrub or small tree, usually up to 3 m tall. Leaves compound with 3 elliptical, ovate to orbicular leaflets, each 5–17 cm × 2–8 cm. In coastal areas and along river banks in the lowlands.

Selected sources 7, 44, 67, 92.

Dicliptera laevigata (Vahl) Jussieu

ACANTHACEAE

Synonyms *Dicliptera javanica* Nees, *Justicia laevigata* Vahl.

Vernacular names Indonesia: pinten (Javanese), jukut jampang (Sundanese).

Distribution Indonesia (eastern parts, Java).

Uses Young shoots are eaten fresh or cooked as a vegetable. Sap from the leaves is used to cure dysentery.

Observations Annual, erect herb, up to 1 m tall. Leaves opposite, with linear cystoliths; petiole 1–4 cm long; leaf-blade ovate, elliptical or oblong, 5–12 cm × 2–7.5 cm, appressed pubescent on the nerves. Flowers pinkish, sometimes white. In humid shady places, up to 1000 m altitude.
The identity of this (cultivated) *Dicliptera* species, eaten as a vegetable, is still unclear. It might also be *D. chinensis* (L.) Nees or *D. burmannii* Nees, two different species with a much wider distribution. The problem will only be solved after a thorough revision of the genus *Dicliptera* Jussieu.

Selected sources 7, 66.

Dicliptera papuana Warburg

ACANTHACEAE

Vernacular names Papua New Guinea: em (Pidgin).

Distribution Papua New Guinea.

Uses Young shoots are eaten raw with pork, but it is not in common use.

Observations Herb, up to 50 cm tall, much branched and often with angular stem. Leaves green, slightly scabrous above, minutely pubescent below; petiole 2–4 cm long; leaf-blade ovate, 4–8 cm × 2.5–5 cm, with about 6 major veins. In mountain vegetation, above 1000 m altitude. Sometimes planted in gardens, propagated from cuttings.

Selected sources 29, 93.

Diplocyclus palmatus (L.) C. Jeffrey

CUCURBITACEAE

Synonyms *Bryonopsis affinis* (Endl.) Cogn., *B. laciniosa* auct., non L. et non (L.) Naudin.

Vernacular names Indonesia: korek kotok (West Java), dudu songot (Java), walaan in cawok (Sulawesi). Papua New Guinea: kongakongo (Pidgin). Philippines: melong-uwak (Tagalog), buntik (Hanunoo), bayong (Bagobo). Thailand: khika-lai (central). Vietnam: (d[aa]y) song qua.

Distribution Indigenous in the Old World tropics, including South-East Asia. It is occasionally cultivated.

Uses Leaves are cooked and eaten as a vegetable in Papua New Guinea (Gazelle Peninsula) and young fruits are eaten cooked in Indonesia (Sulawesi).

Observations Climbing, perennial herb with underground tuber. Stem 3–6 m long, ribbed, tendrils 2-fid. Leaf-blade ovate-cordate in outline, 3–20 cm × 4–22 cm, 3–5-palmatilobed, lobes lanceolate to elliptical; petiole 2–10 cm long. Fruit a subglobose berry, 4 cm in diameter, solitary or in groups of 2–5, green with white streaks, turning red at maturity. The plant is not really cultivated and mainly gathered from the wild where it occurs in humid forest and brushwoods, up to 1800 m altitude.

Selected sources 7, 29, 33, 36, 44, 56.

Feroniella lucida (Scheffer) Swingle

RUTACEAE

Synonyms *Feronia lucida* Scheffer.

Vernacular names Indonesia: kawista-krikil (Java). Cambodia: ka sang, cra san. Laos: sang. Thailand: ma sang. Vietnam: da da, canthan.

Distribution Thailand, Indo-China, Java. Occasionally cultivated.

Uses Raw fruit pulp is used as a vegetable. The wood is hard, but rarely used.

Observations Tree, up to 25 m tall with horizontally arranged branches, spiny or unarmed. Leaves composite, about 8 cm long with 3–11 leaflets. Flowers white, 2–3 cm in diameter, odoriferous, male or bisexual. Fruit a hard-shelled, globose berry, 6–7 cm in diameter, with white or yellowish pulp. In habit and ecology, *F. lucida* resembles the wood apple (*Limonia acidissima* L.), preferring a monsoon or seasonally dry tropical climate. In Central Java often found in teak forest on seasonally very dry soil, up to 400 m altitude. The form with yellowish fruit pulp is said to be toxic (might be *F. pubescens* Tanaka); the fruits with white pulp are sold on markets in Indo-China.

Selected sources 7, 20, 44, 54.

Ficus botryocarpa Miquel

MORACEAE

Synonyms *Ficus conora* King.

Vernacular names Indonesia: musur (Ambon). Philippines: basikong (Manobo).

Distribution Indonesia (Sulawesi, the Moluccas), New Guinea and the Philippines.

Uses Young leaves and figs are eaten raw or boiled as a vegetable with rice.

Observations A cauliflorous tree. Leaves short-petiolate, distichous, ovate to oblong, glabrous or scabrid, symmetrical, pale red when young. Fruit a fig, globose, 2–5 cm in diameter, spotted green. In forest at low altitudes.

Selected sources 24, 44, 61.

Ficus copiosa Steudel

MORACEAE

Synonyms *Ficus polycarpa* Roxb.

Vernacular names Indonesia: wiladan, uyauyahan (Javanese). Papua New Guinea: kumu mosong (Pidgin).

Distribution From Java and Sulawesi (Indonesia) to the Solomon Islands and Queensland (Australia). In Papua New Guinea also cultivated.

Uses Young leaves, buds and shoots are eaten as a vegetable cooked in coconut milk or steam-roasted, especially in Papua New Guinea. Fruits are eaten raw.

Observations Small tree up to 5(–10) m tall. Leaves alternate, crowded at the apices of stems, scabrid by many bristles, especially below; petiole 2–10 cm long; leaf-blade oblong-ovate, 12–25 cm × 6–10 cm, rounded or cordate at base, margins coarsely serrate-dentate, apex shortly acuminate. Fruit a fig, fascicled on the twigs or borne on the stem and old branches, globular, 1–2 cm in diameter, greenish-brown. In mixed forest, up to 2200 m altitude. Propagation is from seed or cuttings. Sometimes it is grown as a hedge and pruned to increase branching.

Selected sources 7, 24, 29, 36, 41.

Ficus dammaropsis Diels

MORACEAE

Synonyms *Dammaropsis kingiana* Warb.

Vernacular names Papua New Guina: kapiak (Pidgin).

Distribution Indigenous to New Guinea where it is also cultivated.

Uses Young leaves are eaten cooked as a vegetable, especially the midrib. Older leaves are used for wrapping up other food during cooking. Fruits are edible, but only eaten in times of scarcity. The bark is used for clothing.

Observations Tree, 5–10 m tall, with strong and flexible branches, containing milky juice. Leaves ovate, up to 90 cm × 60 cm, very variable in size and colour. Fruit a fig, large, up to 15 cm in diameter, covered by large overlapping lateral bracts, rose-red to reddish-brown. In temporary clearings by streams and rivers, and in secondary forest, up to 1000–2300 m altitude. Propagation is from seed. The tree resembles a breadfruit tree (*Artocarpus altilis* (Parkinson) Fosberg) and has the same name in Pidgin.

Selected sources 24, 25, 29, 36, 57.

Ficus fistulosa Reinw. ex Blume

MORACEAE

Synonyms *Ficus repandifolia* Elmer.

Vernacular names Common yellow stem fig (En). Indonesia: benying (Sundanese), lolo (Javanese), kujajing (Kalimantan). Malaysia: kedebu, ara serapat, kelampong bukit. Philippines: tibig (Tagalog), siau (Bicol), basikong (Manobo). Thailand: ching-khao, ching-ban (southern). Vietnam: sung b[oo]ng.

Distribution From India to southern China and throughout Malesia.

Uses Young fruits and shoots are eaten raw as a vegetable.

Observations Evergreen tree, 7–15 m tall, with yellow latex. Leaf-blade elliptical to obovate, 7–33 cm × 2–15 cm, entire or shallowly serrate, thinly coriaceous; petiole 1–6 cm long. Fruit a fig, globular or broadly ellipsoid, 1.5–3 cm in diameter; fruit stalk up to 4 cm long; in fascicles on stem and thick branches. In open forest, forest-edges, in hedges and thickets, up to 2100 m altitude.

Selected sources 7, 20, 24, 26, 44, 66.

Ficus grossularioides Burm.f.

MORACEAE

Synonyms *Ficus alba* Reinw. ex Blume.

Vernacular names White-leafed fig (En). Indonesia: kebak (Javanese), seuhang (Sundanese). Malaysia: ara perah, kelumpong burong.

Distribution Peninsular Thailand, Peninsular Malaysia, Indonesia (Java, Sumatra, Kalimantan).

Uses Young shoots are eaten as salad with rice.

Observations Evergreen shrub or small tree, up to 10 m tall, containing white latex. Sapling leaves cordate, 3–5-lobed, 20–35 cm × 10–23 cm; adult leaves elliptical, 5–15 cm × 2.5–7.5 cm, toothed; leaves characteristically white and finely woolly on underside. Fruit a globular fig, 1–1.5 cm in diameter, mostly on twigs just below the leaves, dark red. In open forest, along streams and forest edges, up to 2100 m altitude.

Selected sources 7, 20, 24, 26, 44, 66.

Ficus nodosa Teijsmann & Binnend.

MORACEAE

Vernacular names Papua New Guinea: jaron, paka, kemkem.

Distribution Indonesia (the Moluccas, Irian Jaya), Papua New Guinea, Solomon Islands.

Uses Young leaves are eaten cooked as a vegetable. Fruits are edible. The bark is used to make rope and clothes.

Observations Tree, up to 40 m tall, trunk with buttresses. Leaf-blade ovate, 12–28 cm × 6–15 cm, entire or slightly toothed; petiole 5–20 cm long. Fruit a globular fig, up to 3 cm in diameter, reddish with yellow flecks and streaks, solitary on twigs and in thick clusters on the trunk and large branches. In high forest, up to 900 m altitude.

Selected sources 24, 31, 69.

Ficus pachyrachis Lauterb. & K. Schum.

MORACEAE

Synonyms *Ficus grandis* King.

Distribution New Guinea.

Uses Young leaves are eaten cooked as a vegetable.

Observations Small tree. Leaves up to 40 cm × 30 cm. Fruit a fig, in scarcely branched clusters on the trunk, yellow-green. Along water courses in primary forest, up to 500 m altitude.

Selected sources 24, 31.

Ficus pseudopalma Blanco

MORACEAE

Synonyms *Ficus blancoi* Elmer.

Vernacular names Philippines: niog-niogan (Tagalog), lamiog (Bisaya), lubi-lubi (Bicol).

Distribution Endemic in the Philippines.

Uses Young leaves are eaten cooked as a vegetable, or raw as a salad. Fruits are used as anthelmintic, especially when dried. Sometimes the tree is planted as an ornamental.

Observations Erect tree looking like a palm, 2–6 m tall. Leaves crowded at the end of the trunk, subsessile; leaf-blade oblanceolate, up to 80 cm long, margins irregularly sinuate-serrate; stipules persistent, 5–7 cm long. Fruit a fig, red or purplish. In dry woods and thickets, up to 1700 m altitude.

Selected sources 24, 32, 61.

Ficus pungens Reinw. ex Blume

MORACEAE

Synonyms *Ficus myriocarpa* Miquel, *F. kalingaensis* Merrill.

Vernacular names Indonesia: ngeseso (Halmahera), gososo (Ternate).

Distribution From the Philippines, through the Moluccas and New Guinea to New Britain.

Uses Young leaves are eaten cooked as a vegetable, especially in Papua New Guinea. In the Moluccas in dry seasons, roots are cut to yield water that is drinkable after boiling. The bark is used to make mats. The latex is said to be very poisonous.

Observations Tree, up to 13 m tall, containing white latex. Branches armed with sharp spines. Leaves large, ovate, 25(–50) × 30 cm, light green when young. Fruit a fig, small, in clusters on long peduncles hanging from the trunk. Near streams and drains, up to 1800 m altitude.

Selected sources 24, 29, 36, 44, 61.

Ficus superba (Miquel) Miquel

MORACEAE

Vernacular names Sea fig (En). Indonesia: jeraka bulu, gedag (Java), keka lampa (Roti). Thailand: krai (Bangkok), sai-liap (southern). Vietnam: sung ki[ee]u.

Distribution From Japan and China throughout South-East Asia to Australia, but not in the Philippines. Occasionally also cultivated.

Uses Young leaves are eaten cooked as a vegetable. Leaves are considered a useful forage, even when older.

Observations Large deciduous tree, up to 30 m tall, epiphytic when young, with numerous aerial roots. Leaves crowded at the apices of stems; leaf-blade elliptical, 12–25 cm × 6–14 cm, pink when young; petiole 4–20 cm long. Fruit a fig, pear-shaped, ca. 2 cm in diameter, bluish-purple, in bunches on small woody knobs on the twigs and branches behind the leaves. On rocky coasts, occasionally a few km inland. A magnificent tree, deserving to be brought into cultivation.

Selected sources 7, 24, 26, 44.

Ficus tinctoria Forster f.

MORACEAE

Synonyms *Ficus gibbosa* Blume, *F. parasitica* Willd.

Vernacular names Humped fig tree (En). Indonesia: kijajawo, pereng, panggang (Java). Papua New Guinea: tagataga (Pidgin). Philippines: baleting-bato (Tagalog), biri, laban (Bisaya). Thailand: krang (central), sai-dam, hai (northern). Vietnam: sung b[aaf]u, sung b[uj]i.

Distribution From India and China to Polynesia, throughout South-East Asia, being the most widely distributed *Ficus* species.

Uses Young shoots are eaten cooked or roasted, especially on New Ireland. Fruits are said to be edible. The bark is rich in tannin and suggested for making bark-cloth for binding books.

Observations Large tree, up to 45 m tall, epiphytic when young, developing many slender aerial roots from the trunk together with many host-strangling basketing roots. Leaf-blade narrowly elliptical, 8–21 cm × 2–9 cm, generally unequally sided and distinctly angled; petiole 0.5–1 cm long. Fruit a fig, subglobose, ca. 1 cm in diameter, orange. Often on rocky sea coasts, in primary and secondary forest, up to 1200 m altitude. The species is very variable and is sometimes divided into 4 subspecies: ssp. *tinctoria* (from Taiwan, through the Philippines, the Moluccas, Sulawesi and New Guinea to Polynesia); ssp. *gibbosa* (Blume) Corner (Thailand, Indo-China, Malaysia, Java, Sumatra); ssp. *parasitica* (Willd.) Corner (Sri Lanka, India, Burma, Indo-China); ssp. *swinhoei* (King) Corner (Taiwan, the Philippines).

Selected sources 7, 20, 24, 26, 29, 36.

Finlaysonia obovata Wallich

ASCLEPIADACEAE

Synonyms *Finlaysonia maritima* Backer ex Heyne.

Vernacular names Indonesia: kalak kambing, oyod kambing (Java). Malaysia: pelir kambing. Philippines: tulus-baybay (Hanunoo). Thailand: kraphopla (eastern). Vietnam: phin lai s[oo]n.

Distribution Widely distributed from India to South-East Asia and Australia.

Uses In the Moluccas the salty leaves are eaten raw.

Observations Woody liana with white latex, up to 5 m long, bark papery. Leaf-blade obovate-oblong to elliptical, 4–15 cm × 2–8 cm, coriaceous, glabrous; petiole 1–2 cm long. Fruit a widely divergent pair of follicles; follicle ovoid, 5–8 cm long, ribbed, hooked acuminate at apex. In mangrove swamps and on banks of tidal rivers.

Selected sources 7, 34, 42, 44.

Galinsoga parviflora Cav.

COMPOSITAE

Vernacular names Yellow weed, gallant soldier (En). Galinsoga à petites fleurs (Fr). Indonesia: bribil, kuningan (Java), balakecut, galinggang, galangsi (West Java). Philippines: galinsoga.

Distribution Native to South America, but now it is a cosmopolitan weed.

Uses Steamed young tops can be eaten as a vegetable. It is also a good fodder.

Observations Annual, erect, branched, slender herb, 20–120 cm tall. Leaves opposite; petiole 2–15 mm long; leaf-blade ovate or ovate-oblong, 1–6.5 cm × 0.5–4.5 cm with three transparent main nerves. Occurring in many localities, usually as a weed in fertile soils under moist conditions from 300–2500 m altitude. Locally very abundant and because of its quick growth it can become a troublesome weed.

Selected sources 7, 66, 85.

Garcinia cowa Roxburgh

GUTTIFERAE

Vernacular names Indonesia: kemenjing (Java), ki ceuri (West Java). Malaysia: kandis. Philippines: bilukau (Tagalog), pildis (Pampanggan), paniginen (Sambali). Thailand: chamuang, muang-som (southern). Vietnam: tai chua.

Distribution From eastern and north-eastern India to Indo-China, wild and cultivated. Occasionally also cultivated outside this area.

Uses Young leaves and shoots are eaten cooked in Burma and Thailand where it is sold in small quantities in local markets. Fruits are edible but very acid. In Vietnam they are an important source of natural citric acid, used for making sour fish or crab soup. The tree yields an inferior gum-resin, resembling gamboge. The tree is sometimes used as rootstock for *G. mangostana* L.

Observations An evergreen, tall to medium-sized, dioecious tree. Leaves broadly lanceolate, 5–7.5 cm long, thick and shiny. Fruit a dull red subglobose berry, 3–5 cm × 2.5–3.5 cm, slightly 6–8-lobed, with orange-yellow pulp. In evergreen and semi-evergreen forest or along streams in valleys.

Selected sources 27, 52, 86, 94.

Glinus oppositifolius (L.) DC.

AIZOACEAE

Synonyms *Mollugo oppositifolia* L.

Vernacular names Indonesia: rumput tapak burung. Philippines: malagoso, sarsalida (Tagalog), papait (Ilocano), kalidtud (Manobo). Cambodia: dang khöm. Laos: daang khôm. Thailand: phakkhuang, sadao-din (central). Vietnam: rau d[aws]ng d[aa]t.

Distribution Tropical Africa and Asia, throughout South-East Asia to northern Australia.

Uses The bitter leaves are cooked, usually with fish or meat. In Thailand leaves are used to cure colds and headaches; they are thirst-quenching. The plant is also reported to promote digestion and salivation and to cure stomach and bowel complaints.

Observations Slender, glabrous, much branched, erect to subprostrate, annual herb, 10–60 cm tall. Leaves in pseudowhorls of 3–5, oblong to obovate or spathulate, 0.6–4.0 cm × 0.3–1.5 cm. In seasonally swampy or inundated and again desiccated localities, up to 400 m altitude. Occasionally cultivated in the Philippines and Thailand as a second crop after rice and sold on local markets. The species probably hybridizes easily with *G. lotoides* L., which occurs in similar habitats but is densely white-hairy.

Selected sources 7, 33, 49, 85, 91.

Gymnema reticulatum (Moon) Alston

ASCLEPIADACEAE

Synonyms *Gymnema syringaefolium* (J. Decaisne) Boerl.

Vernacular names Indonesia: sajor pepe, uta mata (the Moluccas). Cambodia: voë toahs. Vietnam: lo[ax] ti.

Distribution Indonesia, Malaysia and Indo-China.

Uses In the Moluccas young leaves and shoots are eaten raw or cooked.

Observations Climbing shrub, 2–4 m long, containing white latex in all parts. Leaf-blade ovate-oblong or broadly ovate, 5–14 cm × 2–16(–19) cm, subglabrous; petiole up to 6 cm long. Fruit a pair of follicles; follicle cylindrical, 9.5 cm × 2.5 cm, conical at apex, thin. In brushwoods and hedges up to 500 m altitude.

Selected sources 7, 44, 54.

Helicia robusta (Roxburgh) R. Br. ex Wallich

PROTEACEAE

Synonyms *Helicia javanica* Blume, *H. philippinensis* Meisner.

Vernacular names Indonesia: kendung. Malaysia: medang keladi, medang layang. Philippines: lakot, salinsi (Tagalog), matabato (Bisaya), gulattan (Ifugao). Thailand: muat-khon (northern), niang-krup, hangkrarok (southern). Vietnam: ch[ej]o thui l[ows]n.

Distribution From India to Indo-China and throughout Malesia, New Guinea excluded.

Uses In Indonesia the young violet shoots are eaten raw as vegetable. The wood is a minor timber.

Observations Shrub to small tree, 5–8(–18) m tall, with rufous pilose branchlets. Leaves obliquely subopposite or 3–4-subverticillate, subcoriaceous; petiole thick, very short; leaf-blade oblong to obovate, 7–40 cm × 4–15 cm, violet and densely hairy all over the undersurface when young, yellowish or bluish-green and entirely glabrous when older, margin serrate or entire. In rain forest of lower mountains, often on watersides, up to 1900 m altitude. Two varieties have been distinguished: var. *robusta* and var. *integrifolia* (Elmer) Sleumer, the latter having entire, often somewhat smaller leaves, occurring only in the Philippines.

Selected sources 7, 52, 66, 84, 91.

Hibiscus surattensis L.

MALVACEAE

Vernacular names Indonesia: jukut riyut, gamet (West Java), lara gurut (Java). Malaysia: asam susur. Philippines: sabnit (Tagalog), barbarinit (Ilocano), labneg (Bisaya). Laos: sômz faayz. Thailand: chamot, somkop (central), somkeng-kheng-pa (northern). Vietnam: b[uj]p x[uw][ows]c, rau chua gai.

Distribution Widespread in the Old World tropics, including South-East Asia, but not in New Guinea.

Uses The acid leaves and fruits are cooked and often eaten with fish. It is sometimes grown for its stem fibres.

Observations An erect or trailing herb or undershrub, up to 2 m tall, often rooting at the nodes, with spiny stem, petioles, pedicels and nerves. Leaf-blade orbicular to transversally elliptical in outline, 4.5–10 cm × 5–14.5 cm, 3–5-palmatilobed or divided, often somewhat hairy; petiole 4–11 cm long with broad leafy stipules. Flowers yellow with dark purple centre. Fruit an ovoid to globose capsule, 1–1.5 cm in diameter, appressed hispid by stiff hairs, enclosed by the calyx. In young secondary vegetation and teak forests, and occasionally in waste places near villages, up to 1200 m altitude.

Selected sources 13, 44, 89.

Houttuynia cordata Thunberg

SAURURACEAE

Vernacular names Indonesia: jukut hanyir. Cambodia: chii yaab kaa. Laos: kh'aaw th'oong. Thailand: phlu-kae (central), phakkhaothong. Vietnam: di[ees]p c[as], gi[aas]p c[as], l[as] gi[aas]p.

Distribution From India to Indo-China, China, Taiwan and Japan. Introduced in Malesia, but rare. Occasionally cultivated, particularly in Thailand and Indo-China.

Uses Crushed leaves have a fish-like fetid odour and are used in salads or as a garnish for several dishes. Dried leaves are used as a drug in China, Japan and Vietnam. In Europe it is an ornamental plant in garden ponds.

Observations Perennial, erect or ascending herb up to 90 cm tall with creeping rhizome. Leaf-blade broadly ovate with cordate base, 3–8.5 cm × 2.5–6.5 cm, palminervous, strongly aromatic; petiole 1–4 cm long. In semi-shaded, marshy localities, preferably in temperate conditions. It can become a troublesome weed.

Selected sources 7, 49, 51, 91.

Hydrocharis dubia (Blume) Backer

HYDROCHARITACEAE

Vernacular names Frog-bit (En). Indonesia: eceng lalaki (West Java), mangon-mangon (Manado). Thailand: phaktao (central), phakpot-ma (northern).

Distribution From southern and eastern Asia to Australia, including South-East Asia.

Uses Young leaves and young inflorescences can be eaten. Plants are cultivated in fish ponds as water cover.

Observations Small, aquatic, free-floating or rooting, fleshy, monoecious herb. Leaves emerged or floating, in rosettes; petiole up to 15 cm long with wide air-channels; leaf-blade ovate-cordate to broadly ovate, 2.5–6 cm × 2.5–7.5 cm, nerves curved, parallel, joining the marginal nerve, connected by straight, parallel cross-veins. Flowers enclosed in an axillary sheath before anthesis; male sheath peduncled with 2–4 pedicelled flowers; female sheath sessile with a solitary pedicelled flower; sepals white; petals white with a yellow base. In pools and marshes, up to 1200 m altitude, locally gregarious.

Selected sources 7, 44, 91.

Hypobathrum microcarpum (Blume) Bakh.f.

RUBIACEAE

Synonyms *Petunga microcarpa* (Blume) DC.

Vernacular names Indonesia: apit, babalan (Java), kihapit (West Java).

Distribution Indonesia (Java, Sumatra).

Uses The astringent, young leaves and shoot tips are eaten raw as vegetable.

Observations Shrub or small tree up to 12 m tall. Leaves narrowly lanceolate, 6–11 cm × 1–3 cm, with very short petioles. In moist places, up to 500 m altitude.

Selected sources 7, 66.

Lasia spinosa (L.) Thwaites

ARACEAE

Vernacular names Indonesia: ngambing, sambeng (Java), sampi (West Java), gali-gali (Sumatra). Malaysia: geli-geli. Laos: pak norm. Thailand: phaknam. Vietnam: rau m[ows]p, m[ows]p r[as]y gai.

Distribution Tropical Asia, from India to New Guinea, including South-East Asia, occasionally cultivated.

Uses After removing the prickles, young leaves and petioles are eaten cooked or fermented. In Indonesia a decoction of the roots is given to women after childbirth whereas in Thailand it is used for bathing the newborn baby.

Observations Large clump-forming, often stoloniferous, prickly herb, erect to decumbent, 0.5–2 m tall. Leaves long-petioled and very variable in shape, sagittate to hastate, large ones 35–65 cm × 5–30 cm, entire to deeply lobed, membranous to coriaceous, usually with prickles beneath. In open swampy localities below 600 m altitude. Sometimes cultivated along fish ponds, and sold in local markets.

Selected sources 7, 38, 44, 49, 66.

Lobelia zeylanica L.

CAMPANULACEAE

Synonyms *Lobelia succulenta* Blume.

Vernacular names Indonesia: ranci jajar (Java), ramu kuya (West Java). Vietnam: b[ax] thu[oos]c, l[oo] b[ee] t[is]ch lan.

Distribution From India to Southern China and Taiwan, throughout South-East Asia, and Fiji

Islands.

Uses In Java young parts are eaten raw, cooked or mixed with other vegetables.

Observations Creeping or ascending herb, 15–100 cm long, stem terete, rooting at the lower nodes. Leaves spirally arranged; petiole up to 2 cm long; leaf-blade ovate to broadly ovate, 1–6 cm × 0.5–3.5 cm, glabrous or puberulous. In shady, humid places, under everwet climatic conditions, up to 1500(–2000) m altitude.

Selected sources 8, 33, 66, 91.

Lycianthes laevis (Dunal) Bitter

SOLANACEAE

Synonyms *Solanum blumii* Nees ex Blume.

Vernacular names Indonesia: bulung (Sundanese). Malaysia: terong chator.

Distribution Not well known. Possibly from India to Indonesia, including Burma, Peninsular Malaysia and Java.

Uses The leaves are eaten raw or steamed as a vegetable. The fruits are edible and said to be sweet. The seeds are used to cure toothache.

Observations Herb or low shrub, up to 2 m tall with zigzag stem and purple flowers. Leaves alternate, petiole up to 4.5 cm long; leaf-blade oblong-lanceolate, 1–25 cm × 1–9.5 cm, oblique at base. Fruit an orange-red berry, 7–10 mm in diameter. In humid forest, up to 3000 m altitude.

Selected sources 7, 20, 44.

Maesa latifolia (Blume) A. DC.

MYRSINACEAE

Synonyms *Maesa blumei* G. Don, *M. pyrifolia* Miquel.

Vernacular names Indonesia: kipeit (West Java).

Distribution Indonesia (Java, Sumatra), wild and cultivated.

Uses Young leaves and shoots, especially the thin glabrous ones, are eaten as vegetable by the Sundanese in West Java.

Observations Erect shrub, 1–6 m tall. Leaves alternate, very variable in shape and size, lanceolate, elliptical to ovate, 1.5–20 cm × 1–12 cm. In mountainous regions at 300–1500 m altitude. Often cultivated in fences and propagated by cuttings or suckers. To get tender leaves, frequent topping is necessary.

Selected sources 7, 66.

Medinilla crassifolia (Blume) Blume

MELASTOMATACEAE

Synonyms *Medinilla hasseltii* Blume.

Vernacular names Indonesia: bongkol, harendong mangandeuh (West Java). Malaysia: lokan jantan.

Distribution Indonesia, Malaysia, the Philippines.

Uses The sour leaves and fruits are eaten.

Observations Exceedingly variable epiphytic shrub, up to 1 m tall, climbing or scrambling. Leaves opposite, glabrous; petiole up to 2 cm long; leaf-blade very variable, ovate-oblong to lanceolate, 8–19 cm × 3–8 cm, coriaceous. Fruit a globose berry, 4–6 mm in diameter, orange to red. Mostly in peat swamp and secondary forest, or disturbed situations at low altitudes, but up to 1000 m.

Selected sources 7, 20, 42, 75.

Millettia eriantha Benth.

LEGUMINOSAE

Synonyms *Whitfordiodendron erianthum* (Benth.) Merrill, *Adinobotrys erianthus* Dunn.

Vernacular names Malaysia: akar kuayah, akar koyah.

Distribution Peninsular Malaysia, southern Thailand.

Uses The very acid fruits are eaten boiled.

Observations Woody forest climber. Leaves imparipinnate, leaflets 5–7. Fruit flattened ovoid, 5 cm × 4 cm, ridged and hairy.

Selected sources 20, 27, 76.

Murdannia Royle

COMMELINACEAE

Major species and synonyms

- *Murdannia nudiflora* (L.) Brenan, synonyms: *Commelina nudiflora* L., *Aneilema malabaricum* (L.) Merrill, *A. nudiflorum* R. Br.
- *Murdannia spirata* (L.) Brueckner, synonym: *Aneilema spiratum* (L.) R. Br. ex C.B. Clarke.

Vernacular names

- *Murdannia*: Indonesia: gewor, tali (in common with other Commelinaceae).
- *M. nudiflora*: Indonesia: jeboran (Java), patuk gagak (West Java). Malaysia: rumput lidah lembu. Philippines: alikbanong (Tagalog), kolkollaasi (Ilocano), bangal (Ifugao). Laos: kaab. Thailand: phakprap, kinkungnoi (northern).

Vietnam: c[or] trai, th[af]i l[af]i tr[aws]ng.
- *M. spirata*: Indonesia: rancamaya, tali said (Sundanese).

Distribution Both species occur from India to China, including South-East Asia, but *M. spirata* has not been reported from New Guinea, Borneo, Sumatra nor Malaysia.

Uses The green plant parts are used as a raw or steamed vegetable. They are used as fodder as well. *M. nudiflora* leaves are also used as a poultice to cure wounds.

Observations Annual (*M. spirata*) or perennial (*M. nudiflora*), creeping and ascending herbs, 10–30 cm (*M. spirata*) or 10–120 cm (*M. nudiflora*) long. Leaves sheathing; leaf-blade ovate (small leaves) to linear (larger leaves), 1.5–25 cm long, in a radical rosette when young (*M. nudiflora*) or ovate-oblong, 0.7–2.5 cm long (*M. spirata*). Flowers actinomorphic, violet in long (*M. nudiflora*) or very short (*M. spirata*) peduncled racemes. Very common in humid to swampy, sunny places up to 1800 m altitude. They are common weeds in rice fields.

Selected sources 7, 20, 44, 60, 61, 66, 76, 85.

Myriophyllum aquaticum (J.M. da Conceicao Vellozo) Verdc.

HALORAGACEAE

Synonyms *Myriophyllum brasiliense* Cambess.

Vernacular names Parrot's feather (En). Indonesia: paris (West Java), gayanggang (South Kalimantan). Thailand: sarai-yipun (Bangkok). Vietnam: rong du[oo]i ch[os].

Distribution Native to South America, but now cultivated and often naturalized worldwide, including South-East Asia.

Uses Shoot tips are occasionally eaten in Java. It is cultivated in fish ponds as a cover or in pots as bonsai-like plant.

Observations Floating or creeping aquatic perennial herb, 30–70 cm long. Leaves in whorls of 5, in outline linear to elliptical, 2–4 cm × 0.5–1 cm, pinnately divided with 10–14 pairs of segments. Fruits are not formed outside South America, but propagation is possible from plant fragments. In freshwater ditches, ponds or mud from 450–1400 m altitude. It sometimes grows abundantly and can obstruct waterways.

Selected sources 7, 85, 91.

Neanotis W.H. Lewis

RUBIACEAE

Major species and synonyms
- *Neanotis hirsuta* (L.f.) Lewis, synonym: *Anotis hirsuta* (L.f.) Boerl.
- *Neanotis indica* (DC.) Lewis, synonym: *Anotis leschenaultiana* Wight & Arnott.

Vernacular names
- *N. hirsuta*: Indonesia: ringitan gunung (Java), jukut kahitutan, kasimbukan (West Java).
- *N. indica*: Indonesia: simbukan lemah (West Java).

Distribution Both species are indigenous to Indonesia.

Uses Although fetid when bruised, plants are eaten as vegetable, raw or steamed.

Observations
- *N. hirsuta*: Erect or decumbent perennial herb, 15–75 cm tall, rooting at the nodes of the terete stem. Leaves opposite, ovate or ovate-oblong, 1–5 cm × 0.5–3 cm, dark green above, pale green beneath. In sunny or somewhat shady, humid places from 800–2100 m altitude, often as a weed in tea or coffee plantations.
- *N. indica*: Similar to *N. hirsuta* but smaller (up to 50 cm tall, leaves 0.5–3.5 cm × 0.5–2 cm) and stem with four ridges or narrow wings. Less common, from 1600–2600 m altitude.

Selected sources 7, 66.

Nymphaea nouchali Burm.f.

NYMPHAEACEAE

Synonyms *Nymphaea stellata* Willd., *Castalia pubescens* (Willd.) Blume.

Vernacular names Water lily, lotus lily (En). Indonesia: tunjung. Malaysia; kelipoh. Philippines: lauas, pulau (Tagalog), talailo (Bisaya). Cambodia: rum'-chầng. Laos: bwà khiiz bèèz, bauna neai. Thailand: bua-phuan, bua-khap (central), bua-phan, bua-sai. Vietnam: s[us]ng lam.

Distribution Africa, from India to Australia, throughout South-East Asia, wild and cultivated.

Uses Rhizomes and flower-stalks are eaten, raw or cooked, especially by the Chinese. Seeds are also edible, raw, cooked or roasted. It is often cultivated for ornamental purposes.

Observations Perennial, aquatic herb with large creeping rhizome. Leaves floating, up to 20 per plant, peltate, ovate-orbicular, 10–30 cm × 8–25 cm, margins dentate. Flowers white, purplish-blue or pinkish, 8–18 cm in diameter, slightly fragrant, on spongy pedicels up to 1.5 m tall. In shallow ponds and lakes up to 500 m altitude.

Selected sources 7, 13, 44, 49, 68.

Ochthocharis bornensis Blume

MELASTOMATACEAE

Vernacular names Indonesia: karamunting. Malaysia: sekulau, sendudok ayer. Vietnam: mua chua.

Distribution Indonesia (Sumatra, Kalimantan, the Moluccas), Malaysia, Papua New Guinea, Cambodia, Vietnam.

Uses The acid leaves and fruits are eaten raw or cooked.

Observations Small tree or shrub, 1–2(–4.5) m tall. Leaf-blade ovate, 5–17 cm × 1–6.5 cm, margin serrulate, 3-nerved; petiole up to 6 cm long. Fruit a subglobular capsule, about 0.5 cm in diameter, black, crowned by the appressed torus. On banks of tidal rivers, in mangrove forest.

Selected sources 27, 37, 44.

Olax psittacorum (Willd.) Vahl

OLACACEAE

Synonyms *Olax scandens* Roxburgh.

Vernacular names Indonesia: wangon (Java), puluur (Madura). Malaysia: meribut, kodak acing. Laos: 'ii thôk, kh'ôôy siêk. Thailand: katokrok (central), phakrut (southern), nangchom (northern). Vietnam: d[uw][ow]ng d[aaf]u leo.

Distribution From the tropical western Himalayas to Indo-China, Peninsular Malaysia and Indonesia (Java, Lesser Sunda Islands).

Uses The tasty young shoots are eaten raw.

Observations More or less scandent shrub, up to 20 m long, young branches patently pubescent, old branches with thorns. Leaves almost distichous, ovate to elliptical or oblong, 2–9.5 cm × 0.3–3.5 cm, thin, coriaceous. In thickets and dry deciduous forest, up to 300 m altitude, often close to the sea.

Selected sources 7, 44, 91.

Osmoxylon palmatum (Lamk) Philipson

ARALIACEAE

Synonyms *Boerlagiodendron palmatum* (Zipp. ex Boerl.) Harms.

Vernacular names Indonesia: daun gurita, pelenda darat (the Moluccas).

Distribution Indigenous to the Moluccas and Sulawesi (Indonesia).

Uses Leaves are eaten as a vegetable. In local medicine they are also applied against gonorrhoea.

Observations Small tree up to 15 m tall. Leaves clustered near the end of the branches; petiole up to 40 cm long, sheathing at base; leaf-blade palmately 5–9-lobed, in outline up to 45 cm in diameter, lobes elliptical with serrate margins. Inflorescence a terminal compound umbel. An understorey tree in primary rain forest.

Selected sources 7, 44, 91.

Paederia verticillata Blume

RUBIACEAE

Vernacular names Indonesia: aroi kahitutan badak, kasimbukan badak (West Java). Malaysia: sekuntut. Philippines: bang-ugan (Bicol), atut-atut (Bagobo), libog (Manobo). Vietnam: rau m[ow].

Distribution Indonesia, Malaysia, the Philippines, Vietnam.

Uses Leaves are eaten raw or steamed as vegetable in West Java.

Observations Offensive smelling, robust climber, 3–10 m long. Leaves ovate to lanceolate, 6–17 cm × 2.5–8 cm, in whorls of 3. In humid forest and on watersides from 75–1250 m altitude. More common and also with edible leaves is *P. foetida* L. (medicinal plant).

Selected sources 7, 66.

Passiflora biflora Lamk

PASSIFLORACEAE

Synonyms *Passiflora lunata* Willd.

Vernacular names Indonesia: ketungkeng, bunga kupu-kupu.

Distribution Native to South America, but cultivated and occasionally escaped pantropically.

Uses Shoots and young leaves are eaten cooked or raw. Flower buds and young flowers are consumed as well. The whole plant may serve as a living fence. In South America the plant is used for medicinal purposes.

Observations Slender, tendrilled climber with a 6–7-ribbed stem, 2–6 m long. Leaves subcoriaceous, 2-lobed or hemi-orbicular or obreniform (lunate), 2.5–10 cm × 4.5–13 cm. Flowers greenish-white and fragrant, 3–3.5 cm in diameter. Fruit globular, 1–2 cm in diameter. Locally cultivated in Java up to 1000 m altitude.

Selected sources 7, 63, 66, 91.

Pastinaca sativa L.

UMBELLIFERAE

Vernacular names Parsnip (En). Pastenaque, patenais (Fr). Philippines: parsnip.

Distribution Native to Europe and temperate Asia. Cultivated mainly in temperate regions all over the world, sometimes in the tropics and subtropics.

Uses In Europe the fleshy aromatic root is eaten, mostly cooked like carrots. In Indonesia (Jakarta) the root is occasionally found in the supermarkets, imported from Australia. Leaves and roots have diuretic properties.

Observations Biennial herb, 30–150 cm tall, with fusiform, fleshy, white taproot and grooved stem. Leaves pinnate; leaflets ovate-oblong, often 3-lobed or deeply divided, 2–13 cm × 1–5 cm. Can be cultivated at higher altitudes (above ca. 900 m) in the tropics.

Selected sources 7, 13, 57, 74, 77, 91.

Persicaria attenuata (R. Br.) Sojak

POLYGONACEAE

Synonyms *Polygonum attenuatum* R. Br., *P. pulchrum* Blume.

Vernacular names Watersmart weed, hairy knotweed (En). Indonesia: jankong, jukut carang (West Java), bendet (Java). Malaysia: johong beraleh. Philippines: subsuban (Tagalog), kakabkab (Maguindanao). Laos: nea paew. Thailand: uang-phetma, phakphai-nam, dokkhaophot. Vietnam: rau ngh[eer].

Distribution Tropical Africa, Asia and Australia.

Uses Leaves are eaten in salads in Indo-China and also in Africa (Benin).

Observations Robust perennial, pubescent herb, up to 1 m tall, older stems hollow, often rooting at the nodes. Leaf-blade narrow-elliptical to narrow-ovate, 5–25 cm × 1–5 cm, often with long white hairs on both sides; petiole up to 3.5 cm long, sheathing at base and with a prominent ocrea. Often forming large patches on and beside water, up to 1000 m altitude. Three subspecies have been distinguished, mainly differing in hairiness and leaf form. In tropical Africa ssp. *africana* K.L. Wilson, in tropical Asia and Australia ssp. *attenuata* and ssp. *pulchra* (Blume) K.L. Wilson. In Vietnam *P. odorata* (Lour.) Sojak is used similarly to *P. attenuata*.

Selected sources 6, 7, 68, 95.

Persicaria orientalis (L.) Spach

POLYGONACEAE

Synonyms *Polygonum orientale* L.

Vernacular names Prince's feather (En). Persicaire de Levant (Fr). Thailand: phakuang. Vietnam: ngh[eer] b[af], ngh[eer] d[oo]ng.

Distribution South, South-East and East Asia, Africa, North America, Australia.

Uses Young shoots are eaten in Indo-China.

Observations Erect or ascending annual herb, 0.5–1 m tall. Leaf-blade ovate-oblong, 5–20 cm × 3–12 cm, hairy on both sides; petiole 2–6 cm long. In humid places, dried-up pools and ditches, often gregarious, up to 850 m altitude.

Selected sources 6, 7, 20.

Persicaria perfoliata (L.) H. Gross

POLYGONACEAE

Synonyms *Polygonum perfoliatum* L.

Vernacular names Indonesia: wedusan (Java), gam(b)et gunung (West Java). Philippines: kangigit (Igorot), ligu (Ifugao). Thailand: somkhom-khiang. Vietnam: rau m[as] ng[oj], th[oof]m l[oof]m gai.

Distribution From India to Japan, including South-East Asia.

Uses The sour young shoots and fruits are eaten mixed with other vegetables. In Vietnamese local medicine the pounded fresh leaves are used to cover snake-bites and boils.

Observations Perennial, much branched, climbing to ascending herb, 1–5 m tall, with spiny stem. Leaf-blade deltoid, 2–8 cm × 2–8 cm, beneath with small prickles on the nerves; petiole 3–13 cm long, spiny; stipules foliaceous, orbicular, 3–4 cm in diameter, amplexicaul. Inflorescence a terminal spike or raceme, 2–3 cm long. Fruit baccate, subglobose, 3 mm in diameter, shiny blue-black. In thickets and hedges, in humid or waterlogged localities, watersides, from 450–1500 m altitude.

Selected sources 7, 66.

Petasites japonicus (Sieb. & Zucc.) Maxim.

COMPOSITAE

Vernacular names Butterbur (En). Indonesia: daun fuki. Japan: fuki. China: feng tou tsai.

Distribution Originally from Japan, China and Korea. Now occasionally cultivated as an ornamental worldwide, sometimes escaping to the wild. Also introduced in Indonesia from Japan.

Uses Peeled petioles serve as a vegetable. Sometimes leaf-blades and young flower buds are also eaten.

Observations Perennial herb, up to 1 m tall, with large, dentate, unlobed leaves, up to 1 m or more broad; petiole 20–80 cm long at harvest. Flowerhead creamy white with yellow-green involucre. Butterbur can be cultivated in the tropics at higher altitudes in wet soils.

Selected sources 48, 57, 90, 97.

Phytolacca acinosa Roxburgh

PHYTOLACCACEAE

Vernacular names Indian poke (En). Vietnam: th[uw][ow]ng l[uj]c.

Distribution From Kashmir to south-western China, Taiwan and Japan. Occasionally introduced and cultivated elsewhere, e.g. in Vietnam.

Uses Young leaves are eaten as a vegetable. In Vietnam often cultivated in pots as a medicinal herb.

Observations Perennial herb, up to 2 m tall. Leaves lanceolate-elliptical, up to 30 cm × 12 cm. Fruit a depressed-globular 8-lobed berry, purple-black, with the lobes hardly connate. In shady wet places.

Selected sources 33, 47, 55, 57.

Phytolacca americana L.

PHYTOLACCACEAE

Synonyms *Phytolacca decandra* L.

Vernacular names Pokeweed (En). Raisin d'Amérique, morelle à grappe (Fr). Laos: kub nyuj (Hmong). Vietnam: th[uw][ow]ng l[uj]c.

Distribution Originating from North America, now cultivated worldwide and sometimes naturalized. In South-East Asia particularly in Indo-China.

Uses Young shoots, when cooked, are used as a vegetable. The red fruits have been used to colour wine, but are slightly toxic. All parts, especially the roots, are used medicinally as narcotic, emetic and purgative. The plant is a common ornamental in temperate climates.

Observations Perennial herb, up to 4 m tall, with branched stems and tuberous roots. Leaves ovate-lanceolate, 10–40 cm × 4–12 cm. Fruit a berry, subglobose, 1.2 cm in diameter, 10-lobed, dark red, in racemose infructescences. The plant is often distributed by birds which eat the fruits.

Selected sources 33, 47, 57, 70.

Phytolacca esculenta Van Houtte

PHYTOLACCACEAE

Vernacular names Pokeweed (En).

Distribution China and Japan, occasionally cultivated elsewhere, e.g. in the Philippines.

Uses Leaves are used as a vegetable. It is also cultivated as an ornamental.

Observations Woody herb, up to 1 m tall. Leaves suborbicular to ovate-elliptical, up to 15 cm long. Fruit a depressed globose berry, purple-black.

Selected sources 13, 47, 57.

Phytolacca octandra L.

PHYTOLACCACEAE

Vernacular names Inkweed, dyeberry (En).

Distribution Native of tropical America, extending form Mexico to Columbia. Elsewhere locally naturalized or cultivated, e.g. in Indonesia.

Uses Young sprouts and leaves can be used as a vegetable.

Observations Herb, 40–60 cm tall with angular stem. Leaves oblong-lanceolate, 6–15 cm × 2–6 cm; petiole 1–3 cm long. Fruit a subglobose berry, about 1 cm in diameter, with 8 longitudinal furrows, black. Near road and watersides, waste places, at about 1700 m altitude in Indonesia.

Selected sources 7, 47, 57, 91.

Plagiostachys crocydocalyx (K. Schumann) Burtt & Smith

ZINGIBERACEAE

Synonyms *Alpinia crocydocalyx* K. Schumann, *Languas crocydocalyx* (K. Schumann) Merrill.

Vernacular names Indonesia: gopak (Kalimantan). Malaysia: gopak, banjang (Sabah, Sarawak).

Distribution Borneo.

Uses The heart of the young shoot is eaten cooked, and has a slightly acid taste. Fibres of the leaf-sheaths are used in matting.

Observations Perennial herb, ca. 2 m tall. Leaf-blade narrowly elliptical, 120–150 cm × 20–22 cm. Inflorescence (appearing near ground level) a dense raceme with yellow flowers; because of early decay of bracteoles and calyx, the inflorescence is covered with copious mucilage, attracting abundant insects.

Selected sources 22, 44, 79.

Pseuderanthemum racemosum (Roxburgh) Radlk.

ACANTHACEAE

Synonyms *Eranthemum racemosum* Roxburgh.

Vernacular names Indonesia: sayor kambing (the Moluccas).

Distribution Indonesia (only known from the Moluccas).

Uses Leaves can be eaten as a vegetable and the whole plant is considered a good forage. It is cultivated as an ornamental for its beautiful flowers.

Observations Woody herb or shrublet, up to 75 cm tall. Leaves opposite, oblong, 5–8 cm × 3–5 cm. Flowers large, pale pink to reddish-white, in terminal racemes. In shady, somewhat humid places.

Selected sources 44, 78.

Pterococcus corniculatus (Smith) Pax & Hoffm.

EUPHORBIACEAE

Synonyms *Plukenetia corniculata* Smith.

Vernacular names Indonesia: aroi tang-tang angin (West Java). Malaysia: chumbai, pina-pina, pepina.

Distribution From northern India to Burma and Thailand, and scattered throughout western Malesia to the Moluccas and Flores.

Uses The sweet leaves are eaten cooked with coconut milk.

Observation Woody climber, 2–3 m tall, glabrous. Leaves cordate-oblong with glands, 7–19 cm × 3–10 cm, dentate. Fruit a conspicuously 4-winged or 4-horned capsule. In young forest from 100–300 m altitude. It is cultivated on sandy soils under shade. Propagation by cuttings or by seed.

Selected sources 2, 3, 4, 7, 20, 44, 86.

Rumex L.

POLYGONACEAE

Major species and synonyms
- *Rumex acetosa* L.
- *Rumex hydrolapathum* Hudson.
- *Rumex patientia* L.
- *Rumex rugosus* Campdera, synonym: *R. ambiguus* Gren.
- *Rumex sagittatus* Thunberg.
- *Rumex vesicarius* L.

Vernacular names
- General: Sorrel (En). Oseille, surelle (Fr). Indonesia: daun suring, surengan.
- *R. acetosa*: Cambodia: slök mchuu. Vietnam: rau chua, rau b[os] x[oo]i, toan th[ar]o.
- *R. hydrolapathum*: Philippines: gabo.
- *R. vesicarius*: Thailand: phakbuak, sompukhaek (northern).

Distribution Worldwide, chiefly in northern temperate regions, sometimes cultivated. In South-East Asia wild plants are mostly escapes from cultivation.

Uses The sour leaves and petioles are eaten raw or cooked as a vegetable, but their use is not very popular in South-East Asia.

Observations Annual (*R. vesicarius*) or perennial, mostly very variable herbs, sometimes more than 2 m tall (*R. sagittatus*). Leaves spirally arranged, the lower ones mostly in a radical rosette (except *R. vesicarius*), sheathing at base and provided with an amplexicaul ocrea. Flowers in spurious whorls which are combined in racemes or panicles. Fruit usually a sharply trigonous samara. Can be cultivated in the tropics at higher altitudes in fertile soil. For good leaf production, the inflorescences should be removed.

Selected sources 7, 13, 44, 53, 57, 66.

Saraca indica L.

LEGUMINOSAE

Synonyms *Saraca bijuga* Prain, *S. harmandiana* Pierre.

Vernacular names Asoka tree (En). Indonesia: soko (Java), saraka. Malaysia: gapis, talan. Laos: sii suub. Thailand: sok (central), som-suk (northern), chumsaeng-nam (southern), dado litaw. Vietnam: v[af]ng anh.

Distribution Indonesia (Java, Sumatra), Malaysia (Peninsular), Laos, Thailand, Vietnam.

Uses Young leaves and flowers (sourish) are edible. Sacred ornamental tree for Buddhists and

Hindus, being the tree under which Buddha was born.

Observations Tree, 10–20 m tall. Leaves paripinnate, rachis 10–50 cm long, pink or purple when young; leaflets in 1–7 pairs, elliptical-ovate to lanceolate, 5–30 cm × 1.5–10 cm. Flowers fragrant, yellow to orange-red, in 3–15 cm long corymbs; sepals 4, ovate-oblong, 5–12 mm × 2–7 mm; petals absent; stamens 6–8. Often along streams in forests and cultivated as ornamental. Flowering is in February, fruiting in May in continental South-East Asia.

Selected sources 7, 20, 27, 33, 84.

Schefflera aromatica (Blume) Harms

ARALIACEAE

Vernacular names Indonesia: panggang puyu, kipuyu (Sundanese), klanting, sahang (Javanese).

Distribution Indigenous to Java (Indonesia).

Uses The aromatic young leaves are eaten raw as vegetable. Sometimes the shrubs are planted to serve as a hedge.

Observations Crooked shrub or small tree, much branched, 5–12 m tall. Leaves alternate, digitately 5–9-foliolate; petiole 16–55 cm long, petiolules 3–13 cm; leaflets ovate, oblong to elliptical, 10–27 cm × 4–9 cm, entire to serrate, studded with fine transparent dots. In forest and on watersides at 500–2250 m altitude. Sometimes cultivated in Java. Propagated easily from cuttings.

Selected sources 7, 57, 66.

Schismatoglottis calyptrata (Roxburgh) Zollinger & Moritzi

ARACEAE

Vernacular names Indonesia: nyampon (Java), solempat (West Java), salimpur (Madura), daun kasisi (the Moluccas). Philippines: alapayi (Tagalog), dalaw bakir (Ilocano), daliri (Bisaya). Thailand: bon-khieo (southern). Vietnam: m[oo]n d[os]c, do[aj]n thi[eej]t.

Distribution South-East Asia, from Burma to New Guinea, occasionally also cultivated.

Uses In Java young leaves, inflorescences and stolons are eaten cooked. It is also used as an ornamental.

Observations Erect stoloniferous herb, up to 1 m tall. Leaf-blade ovate-oblong to hastate, in outline 10–25 cm × 5–15 cm, with transparent dots and close-set lateral nerves; petiole up to 60 cm long, sheathing in lower half. Inflorescence solitary or fascicled, peduncle 5–7 cm long, spathe tubular inrolled, 4–7 cm long, spadix 3–5 cm long. In moist, shady, preferably stony localities, up to 1600 m altitude. Can be propagated by planting pieces of stolon.

Selected sources 7, 44, 66.

Scleria biflora Roxburgh

CYPERACEAE

Synonyms *Scleria tessellata* (non Willd.) Nees.

Vernacular names Indonesia: ilat lalab (West Java). Philippines: katabod (Tagalog). Vietnam: c[uw][ow]ng hai hoa.

Distribution From India to southern China and the Ryukyu Islands, throughout South-East Asia, but not in the Moluccas and New Guinea.

Uses In Java very young plants are eaten as vegetable, raw or steamed, often mixed with other vegetables.

Observations Annual, tillering, erect herb, up to 1 m tall. Leaves linear, 5–25 cm × 0.3–0.7 cm. Fruit a white nut, globose, 2 mm in diameter, deeply regularly cancellate and pitted, black tipped. The red roots smell strongly of camphor. In swampy localities up to 600 m altitude.

Selected sources 7, 66, 91.

Scorzonera hispanica L.

COMPOSITAE

Vernacular names Scorzonera, black salsify (En). Scorsonère (Fr). Indonesia: tanaman hitam.

Distribution Native to central and southern Europe where it also grows wild. Cultivated all over the world, but mainly in the Mediterranean region.

Uses After peeling and boiling, the sweet root is eaten cooked or in soups. Young (blanched) leaves can be eaten in salads. Roots are also medicinal, containing inulin, a sugar substitute for diabetics.

Observations Perennial, erect, much branched herb, 0.25–1.5 m tall with milky juice. Taproot long, fleshy, skin blackish-brown, inside white. Leaves alternate, entire or dentate, subglabrous, lower ones subradical, lanceolate-spathulate, 5–50 cm × 1–7 cm, higher ones sessile, linear-lanceolate, much smaller. Propagation is by seed. Planting distance 10 cm × 25 cm. The roots are harvested when they are 30–35 cm long. In the tropics it can be cultivated at higher altitudes,

preferably in light soils.
Selected sources 7, 9, 28, 53, 65.

Sesuvium portulacastrum (L.) L.

AIZOACEAE
Vernacular names Samphire, seaside purslane (En). Pourpier maritime (Fr). Indonesia: gelang pasir, gelang laut (Java), karokot (Madura). Malaysia: gelang laut, sepit. Philippines: dampalit (Tagolog), bilang-bilang (Bisaya), kokobarangka (Tagbanua). Cambodia: 'ânluëk preah. Thailand: phakbia-thale (central), phaengphuai-thale (southern). Vietnam: h[ar]i ch[aa]u, phi[ee]n h[aj]ch.
Distribution Pantropical.
Uses The very salty plants can be eaten after repeated boiling in fresh water.
Observations Creeping, succulent, perennial herb, up to about 80 cm long. Stems often reddish and rooting at the nodes. Leaves narrow and fleshy, linear-lanceolate, 1–7 cm × 0.6–1.5 cm. Flowers with numerous pinkish filaments. On seashores and in tidal mud.
Selected sources 7, 13, 33, 66, 91.

Smilax leucophylla Blume

SMILACACEAE
Synonyms *Smilax glycyphylla* Hassk., *S. vicaria* Kunth.
Vernacular names Indonesia: canar bokor (West Java). Malaysia: canar bokor, ubi danau, akar banar. Philippines: sarsaparillang-puti, hampas-tikbalang (Tagalog), banag (Tagbanua), banal (Igorot).
Distribution Indonesia (Java, the Moluccas), Peninsular Malaysia, Borneo, the Philippines.
Uses Young shoots and leaves are edible. Stem usable as a substitute for rattan. In Malaysia pounded leaves and roots are used in a lotion to cure ulceration of the nose.
Observations Robust climbing shrub, up to 20 m long, armed with patent or recurved prickles on the stem. Leaves broadly ovate to ovate-oblong, 10–32 cm × 4–22 cm, coriaceous, pruinose beneath. In mixed forest up to 1100 m altitude.
Selected sources 7, 13, 20, 27, 44.

Smilax megacarpa A. DC.

SMILACACEAE
Vernacular names Malaysia: akar kelona, akar banar. Laos: khüang khau. Vietnam: cam [is]ch, kim cang, kim cang tr[as]i to, c[aaj]m cang q[ur]a to.
Distribution From northern India to Hainan, including Burma, Thailand, Indo-China and Peninsular Malaysia.
Uses The red rhizome is edible. Fruits may also be edible. In Laos the plant is used against coughs and as a medicine for women after childbirth.
Observations Climbing rhizomatous shrub, 2–6 m long, with terete stems, armed with prickles. Leaves very variable, ovate to broadly elliptic, 6–27 cm × 2–15 cm, subcoriaceous. Fruit a juicy red berry, 1.5–2 cm in diameter. In evergreen forest, at altitudes of 300–1800 m.
Selected sources 20, 27, 33, 49, 84.

Solanum muricatum Aiton

SOLANACEAE
Synonyms *Solanum variegatum* Ruiz & Pavón, *S. guatemalense* Hort.
Vernacular names Pepino, melon pear (En). Malaysia: melon pear.
Distribution Native to the Andean Highlands of South America where it is a very ancient crop plant. It does not occur in a wild state. Nowadays it is also becoming popular in other parts of the world, e.g. the United States, New Zealand, the Mediterranean and Malaysia (Cameron Highlands).
Uses Fruits of pepino can be eaten as a cooked vegetable but also raw as a dessert fruit or in sweet dishes. It has a mild sweet flavour and is juicy; usually it is peeled before consumption.
Observations Perennial herb, often cultivated as an annual, about 1 m tall. Leaves very variable, from simple to compound with 3–7 leaflets; simple leaf and leaflets broadly lanceolate to nearly ovate, small to large. Flowers violet to blue. Fruit a berry, ovoid, 6–14 cm × 5–8 cm, light green to creamy white or blue, often striped purple. Pepino is propagated by cuttings. It can be cultivated in the cooler parts of the tropics (highlands). The soil should not be too fertile. The plants are not very drought resistant. Much research on this species is done in New Zealand, where it has become a rather important commercial crop.
Selected sources 18, 40, 64.

Solena amplexicaulis (Lamk) Gandhi

CUCURBITACEAE

Synonyms *Melothria heterophylla* (Lour.) Cogn., *Solena heterophylla* Lour.

Vernacular names Indonesia: tingkesan (Java), kilong layong (West Java). Malaysia: timun tikus. Cambodia: mreach khmaôch. Laos: tam-nin. Thailand: tamlung-tuaphu. Vietnam: hoa b[as]t, c[aa][uf] qua.

Distribution From India to China and Australia, including South-East Asia, but not in the Philippines.

Uses Unripe fruits can be eaten cooked or raw as a vegetable.

Observations Extremely variable, dioecious, climbing herb, 1.5–3 m long. Leaf-blade polymorphous, ovate-triangular to narrowly sagittate, entire or more of less 3–5-lobed, in outline 4–10 cm × 3–9 cm. Tendrils very long, simple. Fruit an oblongoid berry, 4–5 cm × 2–2.5 cm, red when ripe. In brushwoods and forest edges.

Selected sources 7, 20, 33, 44.

Spathiphyllum commutatum Schott

ARACEAE

Vernacular names Indonesia: tundah (Bentiang), gogotola (Halmaheru). Philippines: aakalan (Bisaya), lukalang (Bicol), almu (Batanes), halili.

Distribution Indonesia and the Philippines, occasionally also cultivated elsewhere.

Uses Young leaves are eaten cooked in Sulawesi. It is also used as an ornamental.

Observations Erect herb, up to 1.5 m tall. Leaf-blade large, broadly elliptical-oblong, 36–45 cm × 17–26 cm, with many lateral veins; petiole sheathing, 45–50 cm long. In forest from 500–1400 m altitude.

Selected sources 7, 13, 19, 44.

Sphenoclea zeylanica Gaertner

CAMPANULACEAE

Vernacular names Wedgewort, gooseweed (En). Indonesia: gunda. Philippines: burat-aso (Tagalog), mais-mais (Bisaya). Cambodia: kâm'-péén tük. Laos: kaad naa. Thailand: phakpot-na. Vietnam: c[or] ph[oor]ng, x[af] b[oo]ng.

Distribution Native to tropical Africa, but now distributed pantropically, including South-East Asia.

Uses The bitter, young shoots or young plants are eaten in Java and Thailand.

Observations Annual, erect, simple or branched herb, up to 1.5 m tall with hollow stem. Leaves spirally arranged, glabrous; petiole up to 3 cm long; leaf-blade oblong to lanceolate-oblong, 2.5–12.5 cm × 0.5–5 cm. Flowers in conical-cylindrical spikes up to 7.5 cm long. In humid soils up to 350 m altitude. A common weed in rice fields. The habit much resembles *Phytolacca* species.

Selected sources 7, 33, 49, 66, 85, 91.

Suaeda maritima (L.) Dumortier

CHENOPODIACEAE

Vernacular names Sea-blite (En). Indonesia: alur, malur (Java). Thailand: chakhram (central). Vietnam: ph[if] di[eej]p bi[eer]n, th[uj]y di[eer]n nam.

Distribution Europe, northern Africa, Asia, Australia, North America.

Uses In Java, young parts of this very salty plant are eaten as a vegetable after boiling .

Observations Perennial, polymorphous, glabrous, much branched, succulent herb, 7–50 cm tall, often partly or entirely purple. Leaves fleshy, narrowly linear, semi-terete, 1–4.5 cm long. On moist, saline, clayey soils near the sea, often growing gregariously.

Selected sources 7, 33, 66, 91.

Taraxacum officinale Weber

COMPOSITAE

Vernacular names Dandelion (En). Pissenlit, dent de lion (Fr). Indonesia: jombang. Vietnam: b[oof] c[oo]ng anh, s[uw] nha.

Distribution Native to Europe and continental, temperate Asia. It is a very common wild plant in temperate regions, distributed now all over the world. Sometimes it is cultivated.

Uses Leaves are eaten as a vegetable. In temperate regions leaves are eaten raw or cooked, preferably blanched. Roots and flowers are edible as well. Dried, ground roots are used as a coffee substitute. Roots and leaves are also used medicinally.

Observations Perennial, stemless, polymorphous herb, up to 40 cm tall, with a long taproot, containing milky juice in all parts. Leaves in a radical rosette, very variable, oblong-spathulate or lanceolate-spathulate, 4–35 cm × 0.75–10 cm, irregularly pinnatilobed or pinnatipartite. Not very common in the tropics and only at high altitudes (above 1200 m) where it can be cultivated as well. Propagation is by seed or by division. It prefers moist localities. Cultivars are available, e.g. 'Amélioré Géant'. The wild species forms a polyploid complex with enormous variability.

Selected sources 7, 15, 65, 66.

Telosma procumbens (Blanco) Merrill

ASCLEPIADACEAE

Vernacular names Philippines: kapuk-kapuk (Tagalog), dugep, kapas-kapas (Ilocano), adwan di dalom.

Distribution Widely distributed but endemic in the Philippines.

Uses Flowers and pericarp of immature fruit are eaten cooked.

Observations Woody climber. Leaf-blade ovate to oblong, 8–13 cm × 3–8 cm. Flowers greenish-yellow, ca. 1.5 cm long. Fruit a lanceolate-ovoid follicle, ca. 15 cm long; seeds with a white coma. In thickets and secondary forest at low altitudes. Easy to cultivate. Suitable for intercropping with fruit trees, because of its twining habit.

Selected sources 13, 60, 61.

Teramnus labialis (L.f.) Sprengel

LEGUMINOSAE

Vernacular names Horse vine, rabbit vine (En). Indonesia: cantingan (Java), kacang tikus (the Moluccas). Philippines: mangkit-bagin (Tagalog), balagun (Bisaya), bagon-bagon (Samal). Cambodia: voë romiet.

Distribution Widespread in tropical Africa and Asia.

Uses Young leaves are eaten in Indonesia. As a pasture plant, it is well accepted by cattle.

Observations A variable, climbing, trailing or prostrate perennial herb, up to 4 m long, with woody rhizome and slender hairy stem. Leaves with 3 round to lanceolate leaflets, 1–9.5 cm × 0.5–5 cm, glabrous or pubescent. In brushwoods, plantations and forest up to 800 m altitude.

Selected sources 33, 44, 92.

Trema cannabina Loureiro

ULMACEAE

Synonyms *Trema virgata* (Planchon) Blume.

Vernacular names Smooth trema (En). Indonesia: delung (South Sumatra), anggrung (Java), bintanong (Borneo). Malaysia: mengkirai lalab, mengkirai padi. Philippines: anagdung (Bisaya), anabiyon (Bicol), inangdon (Mangyan). Vietnam: hu day, tr[aaf]n mai cong.

Distribution South-East Asia, Australia, Melanesia, West Polynesia and Micronesia.

Uses The Malay name suggests that the plant is edible but there is no confirmation of this.

Observations Shrub or small, much branched tree, up to 6 m tall. Leaves ovate-caudate to broadly ovate-acute or elliptical-lanceolate, 3–13 cm × 1.5–5.5 cm, glabrous, rarely sparsely pubescent beneath. Branchlets initially densely silvery-hairy. Fruit a very small orange to red drupe. Pioneer in newly opened-up habitats up to 1200 m altitude.

Selected sources 7, 20, 91.

Trianthema portulacastrum L.

AIZOACEAE

Vernacular names Horse purslane (En). Pourpier couran (Fr). Indonesia: krokot, telekan (Java). Papua New Guinea: pih-suh. Philippines: toston (Tagalog), ngatug (Ilocano), ayam (Bisaya). Cambodia: chongkuëng' praëhs. Thailand: phakbia-hin, phakkhom-hin (central). Vietnam: c[or] tam kh[oo]i, d[af]n d[af]n.

Distribution Pantropical.

Uses Sometimes young tops and leaves are eaten.

Observations Annual, succulent, prostrate or ascending herb, up to about 60 cm tall. Leaves opposite, ovate, obovate, obcordate or oblong, 0.8–5 cm × 0.4–4.5 cm, those of the same pair very unequal in size, purple-margined, not distinctly papillate. A common weed in cultivated ground and in open, sunny localities, often near the sea, up to 200 m altitude.

Selected sources 7, 13, 33, 63, 91.

Valerianella locusta (L.) Laterrade

VALERIANACEAE

Synonyms *Valerianella olitoria* (L.) Pollich.

Vernacular names Corn salad, lamb's lettuce

(En). Mâche (Fr).

Distribution Native to Europe and the Mediterranean. Occasionally also cultivated, mainly in temperate countries. On trial in Papua New Guinea.

Uses The whole plant is used in salads.

Observations Annual, somewhat succulent herb, 7–25 cm tall. Leaves spathulate to lanceolate-oblong. In the tropics it can be cultivated at higher altitudes. Propagation by seed. Whole plants are harvested when having 8–12 leaves, before the stem develops.

Selected sources 20, 43, 50.

Vallaris solanacea (Roth) O. Kuntze

APOCYNACEAE

Synonyms *Vallaris heynei* Sprengel.

Vernacular names Indonesia: cungkangkang beurit (West Java). Malaysia: bunga tongkeng. Cambodia: voë kâm'-baô. Thailand: chama nat, chammanat-lek (central), ya-changnoi (northern). Vietnam: d[aa]y h[of]a li[eej]t.

Distribution From India to Indo-China. Occasionally also cultivated and naturalized elsewhere.

Uses In Thailand young leaves, flowers and fruits are eaten. In India the latex is applied to sores and wounds.

Observations Liana, up to 20 m long, woody at base, containing white latex. Leaves decussate, elliptical to oblong, 5–12 cm × 2.5–4 cm, chartaceous. Flowers creamy white, about 2.5 cm in diameter, fragrant, in axillary, drooping cymes. Fruit a pair of connate follicles, cylindrical, up to 20 cm × 2.5 cm, with beaked seeds that have a tuft of white hairs. From sea-level up to 900 m altitude. Fruiting is rare.

Selected sources 20, 57, 59, 94.

Vallisneria L.

HYDROCHARITACEAE

Major species and synonyms

- *Vallisneria natans* (Loureiro) Hara, synonym: *V. gigantea* Graebner.
- *Vallisneria spiralis* L.

Vernacular names Eelgrass, tapegrass (En). Indonesia: rumput belut. Philippines: sintas-sintasan, sabotan-buwaya (Tagalog), balaiba (Ilocano), mariw-bariw (Bicol). Thailand: santawa-baikhao (central), santawa-khonkai (southern). Vietnam: rong m[as]i ch[ef]o, (rong) t[os]c ti[ee]n.

Distribution Tropics and subtropics and warmer parts of the temperate regions of the world.

Uses Young leaves can be eaten cooked or raw. Also widely used as an ornamental in aquariums.

Observations

- *V. natans*: Herbaceous, submerged aquatic plant. Leaves ribbon-like, up to 2 m long, 0.5–2 cm broad, margins faintly dentate, 5–9-nerved.
- *V. spiralis*: Similar to *V. natans* but leaves narrower, up to 1 cm broad, entire and always 5-nerved.

In fresh, shallow, quiet or slow-running water up to 300 m altitude. Often growing in dense vegetations. The species have not yet been properly defined for easy distinction.

Selected sources 13, 68, 91.

Sources of literature

1. Airy Shaw, H.K., 1969. Notes on Malesian and other Asiatic Euphorbiaceae. Kew Bulletin 23: 2–131.
2. Airy Shaw, H.K., 1972. The Euphorbiaceae of Siam. Kew Bulletin 26: 191–363.
3. Airy Shaw, H.K., 1981. The Euphorbiaceae of Sumatra. Kew Bulletin 36: 239–374.
4. Airy Shaw, H.K., 1982. The Euphorbiaceae of Central Malesia. Kew Bulletin 37: 1–40.
5. Association of Applied Botanists, 1984. Aspects of applied biology 6. Agronomy, physiology, plant breeding and crop protection of oilseed rape. 26–28 March, 1984, Cambridge, U.K. Association of Applied Botanists, Wellesbourne, United Kingdom. 419 pp.
6. Backer, C.A., 1928–1934. Onkruidflora der Javasche suikerrietgronden. Handboek ten dienste van de suikerriet cultuur en de rietsuiker fabricage op Java [Weed flora of Javanese sugar-cane fields. Handbook for the cultivation of sugar-cane and manufacturing of cane-sugar in Java]. Vereniging het Proefstation voor de Java-Suikerindustrie. 4 volumes. 907 pp.
7. Backer, C.A. & Bakhuizen van den Brink Jr, R.C., 1963–1968. Flora of Java. 3 volumes. Wolters-Noordhoff, Groningen, the Netherlands. Vol.1 (1963) 647 pp., Vol.2 (1965) 641 pp., Vol. 3 (1968) 761 pp.
8. Backer, C.A. & van Slooten, D.F., 1924. Geïllustreerd handboek der Javaansche theeonkruiden en hunne betekenis voor de

cultuur [Illustrated handbook of weeds of Javanese tea plantations and their significance for tea-growing]. Ruygrok, Batavia, Dutch East Indies. 308 pp.
9. Bailey, L.H., 1975. Manual of cultivated plants. 15th printing of 1951 edition (1st edition, 1924). Macmillan, New York, United States. 1116 pp.
10. Banerjee, A., Bagchi, D.K. & Matai, S., 1985. Allmania nodiflora (Amaranthaceae), a promising source of leaf protein. Aquatic Botany 22(3–4): 393–396.
11. Barrau, J., 1962. Les plantes alimentaires de l'Océanie, origines, distribution et usages [The edible plants of Oceania, origins, distribution and uses]. University of Aix-Marseille, Faculty of Sciences, Thesis No 71. 275 pp.
12. Bates, D.M., Robinson, R.W. & Jeffrey, C. (Editors), 1990. Biology and utilization of the Cucurbitaceae. Comstock, Cornell University Press, Syracuse, New York, United States. 485 pp.
13. Brown, W.H., 1941–1943. Useful plants of the Philippines. 3 volumes. Department of Agriculture and Natural Resources. Technical Bulletin 10. Bureau of Printing, Manila, the Philippines. 1610 pp. (reprint, 1951–1957).
14. Brücher, H., 1977. Tropische Nutzpflanzen. Ursprung, Evolution und Domestikation [Tropical useful plants. Origin, evolution and domestication]. Springer-Verlag, Berlin, Germany. 529 pp.
15. Brückner, K., 1953. Zur Sorten- und Anbaufrage sowie Verwendung des Kultur-Löwenzahns [Races, cultivation and use of the cultivated dandelion] (Taraxacum officinale Web.). Pharmazie 8: 1043–1051.
16. Buijsen, J.R.M., 1990. Taxonomic survey of Allium species cultivated in South-East Asia. Mimeographed report. Rijksherbarium, Leiden, the Netherlands. 47 pp.
17. Buishand, T., 1991. De Mexicaanse augurk. Een kansrijke klimplant voor de koude grond [The Mexican gherkin. A climber with potential for growing outdoors]. Groei en Bloei 8: 40–41.
18. Buishand, T., 1992. Pepino, produktieve potplant voor terras en balkon [Pepino, productive potplant for terrace and balcony]. Groei en Bloei 4: 77–78.
19. Bunting, G.S., 1961. The cultivated species of Spatiphyllum. Baileya 9: 109–117.
20. Burkill, I.H., 1935. A dictionary of the economic products of the Malay Peninsula. 2 volumes. Crown Agents for the Colonies, London, United Kingdom. 2402 pp. (slightly revised reprint, 1966. 2 volumes. Ministry of Agriculture and Cooperatives, Kuala Lumpur, Malaysia. 2444 pp.).
21. Burtt, B.L., 1970. Studies in the Gesneriaceae of the Old World 33: some species of Cyrtandra, chiefly Bornean. Notes from the Royal Botanic Garden Edinburgh 30: 23–42.
22. Burtt, B.L. & Smith, R.M., 1972. Notes on Malesian Zingiberaceae. Notes from the Royal Botanic Garden Edinburgh 31: 307–316.
23. Busson, F., 1965. Plantes alimentaires de l'Ouest africain [Food plants of West Africa]. Ministère de la Coopération, Paris, France. 568 pp.
24. Corner, E.J.H., 1965. Checklist of Ficus in Asia and Australasia with keys to identification. The Gardens' Bulletin Singapore 21(1): 1–186.
25. Corner, E.J.H., 1978. Ficus dammaropsis and the multibracteate species of Ficus sect. Sycocarpus. Philosophical transactions of the Royal Society of London. B. Biological sciences 281: 373–406.
26. Corner, E.J.H., 1988. Wayside trees of Malaya. 3rd edition. 2 volumes. The Malayan Nature Society, Kuala Lumpur, Malaysia.
27. Corner, E.J.H. & Watanabe, K., 1969. Illustrated guide to tropical plants. Hirokawa Publishing Co., Tokyo, Japan. 1147 pp.
28. Criel, D., 1989. Bijzondere groenten in uw moestuin [Unusual vegetables in your vegetable garden]. Zomer & Keuning Boeken, Ede, the Netherlands. 251 pp.
29. Department of Primary Industry, 1983. Leafy vegetables. Farming notes 30. Department of Primary Industry, Port Moresby, Papua New Guinea. 40 pp.
30. de Wilde-Duyfjes, B.E.E., 1976. A revision of the genus Allium L. (Liliaceae) in Africa. Mededelingen Landbouwhogeschool Wageningen 76-11. 239 pp.
31. Diels, L., 1935. Die Moraceen von Papuasien [The Moraceae of Papuasia]. Botanische Jahrbücher 67: 171–235.
32. FAO, 1984. Food and fruit-bearing forest species. 2. Examples from southeastern Asia. FAO Forestry paper 44/2. Rome, Italy. 167 pp.
33. Flore du Cambodge, du Laos et du Vietnam [Flora of Cambodia, Laos and Vietnam] (various editors), 1960– . Vol. 1–24. Muséum National d'Histoire Naturelle, Laboratoire de Phanérogamie, Paris, France.

34. Forster, P.I., 1989. Notes on Asclepiadaceae, 1. Austrobaileya 3: 109–133.
35. Forster, P.I., 1991. A taxonomic revision of Cynanchum L. (Asclepiadaceae: Asclepiadoideae) in Australia. Austrobaileya 3: 443–466.
36. French, B.R., 1986. Food plants of Papua New Guinea, a compendium. Australia Pacific Science Foundation. 407 pp.
37. Hansen, C. & Wickens, G.E., 1981. A revision of Ochthocharis (Melastomataceae), including Phaeoneuron of Africa. Kew Bulletin 36: 13–30.
38. Hay, A., 1988. Cyrtosperma (Araceae) and its Old World allies. Blumea 33: 427–469.
39. Hegi, G., 1906–1931. Illustrierte Flora von Mitteleuropa [Illustrated flora of Central Europe]. Vols. 1–7. Lehmanns Verlag, München, Germany. (second and third editions 1935– .)
40. Heiser, C.B., 1964. Origin and variability of the pepino (Solanum muricatum): a preliminary report. Baileya 12: 151–158.
41. Henderson, C.P. & Hancock, I.R., 1988. A guide to the useful plants of Solomon Islands. Ministry of Agriculture and Lands, Honiara, Solomon Islands. 481 pp.
42. Henderson, M.R., 1959. Malayan wild flowers: dicotyledons. The Malayan Nature Society, Kuala Lumpur, Malaysia. 478 pp.
43. Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. 525 pp.
44. Heyne, K., 1927. De nuttige planten van Nederlandsch Indië [The useful plants of the Dutch East Indies]. 2nd edition. 3 volumes. Departement van Landbouw, Nijverheid en Handel in Nederlandsch Indië. 1953 pp. (3rd edition, 1950. van Hoeve, 's-Gravenhage/Bandung, the Netherlands/Indonesia. 1660 pp.).
45. Holttum, R.E., 1950. The Zingiberaceae of the Malay Peninsula. The Gardens' Bulletin Singapore 13(1): 1–282.
46. Hotta, M., Ogata, K., Nitta, A., Hosikawa, K., Yanagi, M. & Yamazaki, K. (Editors), 1989. Sekai yuhyou-shokubutu jiten [Useful plants of the world]. Heibonsha, Tokyo, Japan. 1499 pp.
47. Huxley, A., Griffiths, M. & Levy, M. (Editors), 1992. The new Royal Horticultural Society dictionary of gardening. 4 volumes. Macmillan Press, London, United Kingdom.
48. Imazu, T., 1961. Morphological, ecological and cytological studies on cultivated and wild butterburs, Petasites japonicus Maxim. I. On the morphology of the leaf, sprouting and flowering habits, and seed germination [in Japanese, English summary]. Journal of the Japanese Society for Horticultural Science 30: 233–240.
49. Jacquat, C., 1990. Plants from the markets of Thailand. Editions Duang Kamol, Bangkok, Thailand. 251 pp.
50. Kroll, R., 1957. De groenteteelt in Belgisch-Congo [Vegetable growing in Belgian Congo]. Directie van Landbouw, Bossen en Veeteelt, Brussel, Belgium. 134 pp.
51. Kuebel, K.R. & Tucker, A.O., 1988. Vietnamese culinary herbs in the United States. Economic Botany 42(3): 413–419.
52. Kurz, W.S., 1877. Forest flora of British Burma. 2 volumes. Office of the Superintendent of Government Printing, Calcutta, India.
53. Lang, R.M., 1989. Fijne en zeldzame groenten [Fine and rare vegetables]. Uitgeverij Terra, Zutphen, the Netherlands. 128 pp.
54. Lecomte, M.H. & Gagnepain, F. (Editors), 1907–1950. Flore générale de l'Indo-Chine [General flora of Indo-China]. 7 volumes and supplements. Muséum National d'Histoire Naturelle, Paris, France.
55. Li, Hui-Lin et al. (Editors), 1975–1978. Flora of Taiwan. 5 volumes. Epoch Publishing Company, Taipei, Taiwan.
56. Lolo, M., 1982. A survey of traditional vegetables in the Gazelle Peninsula, East New Britain. In: Proceedings of the Second Papua New Guinea Food Crops Conference, July 14–18, 1980, Goroka. Department of Primary Industry, Port Moresby, Papua New Guinea. pp. 148–159.
57. Mansfeld, R., 1986. Verzeichnis landwirtschaftlicher und gärtnerischer Kulturpflanzen (ohne Zierpflanzen) [Register of agricultural and horticultural plants in cultivation (without ornamentals)]. Schultze-Motel, J. et al., editors 2nd edition, 4 volumes. Springer Verlag, Berlin, Germany. 1998 pp.
58. Marzi, V. & Lattanzio, V. (Editors), 1981. Studi sul carciofo [Studies on artichoke]. Industria Grafica Laterza, Bari, Italy. 1127 pp.
59. Matthew, K.M., 1981–1983. The flora of the Tamilnadu Carnatic. 3 volumes. The Rapinat Herbarium, Tiruchirapalli, India.
60. Merrill, E.D., 1912. A flora of Manila. Bureau of Printing, Manila, the Philippines. 491 pp.

61. Merrill, E.D., 1923–1926. An enumeration of Philippine flowering plants. 4 volumes. Bureau of Printing, Manila, the Philippines. 463, 530, 628, 515 pp. respectively.
62. Michellon, R., 1985. Comparaison de variétés de chicorée de Bruxelles (endive) à la Réunion [Comparison of endive cultivars in Réunion]. l'Agronomie Tropicale 40(1): 40–43.
63. Morton, J.F., 1981. Atlas of medicinal plants of Middle America (Bahamas to Yucatan). C.C. Thomas Publisher, Springfield, Illinois, United States. 1420 pp.
64. National Research Council, 1989. Lost crops of the Incas: little-known plants of the Andes with promise for worldwide cultivation. National Academy Press, Washington, D.C., United States. 415 pp.
65. Nicholson, B.E., Harrison, S.G., Masefield, G.B. & Wallis, M., 1969. The Oxford book of food plants. Oxford University Press, United Kingdom. 206 pp.
66. Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische groenten', 1931). Asher & Co., Amsterdam, the Netherlands. 1016 pp.
67. Ohashi, H., 1973. The Asiatic species of Desmodium and its allied genera (Leguminosae). Ginkgoana 1: 1–318.
68. Pancho, J.V. & Soerjani, M., 1978. Aquatic weeds of South-East Asia; a systematic account of common Southeast Asian aquatic weeds. National Publishing Cooperative, Quezon City, the Philippines. 130 pp.
69. Peekel, P.G., 1984. Flora of the Bismarck Archipelago for naturalists. English edition. Office of Forests, Division of Botany, Lae, Papua New Guinea. 638 pp.
70. Petelot, A., 1952–1954. Les plantes médicinales du Cambodge, du Laos et du Vietnam [Medicinal plants of Cambodia, Laos and Vietnam]. 4 volumes. Archives des Recherches Agronomiques et Pastorales au Vietnam No 14, 18, 22, 23. Vietnam.
71. Phongpha-ngan, S., 1972. Phuet kindai [Edible plants]. Witthayasart [Science] 26(4): 9–15.
72. Polhill, R.M., 1971. Some observations on generic limits in Dalbergieae – Lonchocarpineae Benth. (Leguminosae). Kew Bulletin 25: 259–273.
73. Poulsen, N.I, 1990. Chives (Allium schoenoprasum L.) In: Brewster, J.L. & Rabinowitch, H.D. (Editors): Onions and allied crops. Vol. 3. Biochemistry, food science, and minor crops. CRC Press, Boca Raton, Florida, United States. pp. 231–250.
74. Purseglove, J.W., 1968–1972. Tropical crops. Longman, London, United Kingdom. Dicotyledons. 2 volumes (1968), 719 pp. Monocotyledons. 2 volumes (1972), 607 pp.
75. Regalado, J.C., 1990. Revision of Medinilla (Melastomataceae) of Borneo. Blumea 35: 5–70.
76. Ridley, H.N., 1922–1925. The flora of the Malay Peninsula. 5 volumes. Government of the Straits Settlements and Federated Malay States. L. Reeve & Co., London, United Kingdom.
77. Roecklein, J.C. & Ping Sun Leung, 1987. A profile of economic plants. Transaction, New Brunswick, United States. 623 pp.
78. Roxburgh, W., 1832. Flora Indica. Carey edition. Reprint 1874. Thacker, Spink & Co., Calcutta, India. 763 pp. + lxiv pp.
79. Schumann, K., 1899. Monographie der Zingiberaceae von Malaisien und Papuasien [Monography of the Zingiberaceae of Malesia and Papuasia]. Botanische Jahrbücher 27: 259–350.
80. Shinohara, S. (Editor), 1984–1989. Vegetable seed production technology of Japan. 2 volumes. Shinohara's Authorized Agricultural Consulting Engineer Office, Tokyo, Japan. Vol. 1 (1984) 432 pp., Vol. 2 (1989) 317 pp.
81. Simmonds, N.W. (Editor), 1976. Evolution of crop plants. Longman, London, United Kingdom. 339 pp.
82. Sleumer, H., 1988. A revision of the genus Ardisia Sw. (Myrsinaceae) in New Guinea. Blumea 33: 115–140.
83. Smith, R.M., 1977. Additional notes on Alpinia sect. Myriocrater. Notes from the Royal Botanic Garden Edinburgh 35(2): 195–208.
84. Smitinand, T. & Larsen, K. (Editors), 1970– . Flora of Thailand. Vol. 2, 3, 4 (1, 2), 5 (1, 2). The Forest Herbarium, Royal Forest Department, Bangkok, Thailand.
85. Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G., 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. 716 pp.
86. Terra, G.J.A., 1966. Tropical vegetables. Communication 54. Royal Tropical Institute, Amsterdam, the Netherlands. 107 pp.
87. Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. 533 pp.

88. Valeton, Th., 1918. New notes on the Zingiberaceae of Java and the Malayan Archipelago. Bulletin du Jardin Botanique de Buitenzorg, Series II 27: 1–227.
89. van Borssum Waalkes, J., 1966. Malesian Malvaceae revised. Blumea 14(1): 1–251.
90. van der Meijden, R., 1990. Heukels' Flora van Nederland [Heukels' Flora of the Netherlands]. 21st edition. Wolters-Noordhoff, Groningen, the Netherlands. 662 pp.
91. van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 1, 4–10. Kluwer Academic Publishers, Dordrecht, the Netherlands.
92. Verdcourt, B., 1979. A manual of New Guinea legumes. Botany Bulletin No 11. Office of Forests, Division of Botany, Lae, Papua New Guinea. 645 pp.
93. Warburg, O., 1894. Plantae Hellwigianae. Beitrag zur Flora von Kaiser Wilhelms-Land [Plants collected by Hellwig. Contribution to the flora of Kaiser Wilhelms-Land]. Botanische Jahrbücher 18: 184–212.
94. Wealth of India (various editors), 1948–1976. A dictionary of Indian raw materials and industrial products: raw materials. 11 volumes. Publications and Information Directorate, Council of Scientific and Industrial Research, New Delhi, India. 4441 pp.
95. Wilson, K.L., 1990. Some widespread species of Persicaria (Polygonaceae) and their allies. Kew Bulletin 45: 621–636.
96. Wunderlin, R.P., 1978. Cucurbitaceae. In: Woodson, R.E. & Schery, R.W. (Editors): Flora of Panama. Annals of the Missouri Botanical Garden 65: 285–368.
97. Yamaguchi, M., 1983. World vegetables: principles, production and nutritive values. Avi Publishing Company, Westport, Connecticut, United States. 415 pp.
98. Zohary, D. & Basnizky, 1975. The cultivated artichoke – Cynara scolymus. Its probable wild ancestors. Economic Botany 29: 233–235.

M.H. van den Bergh

4 Vegetable-producing plants with other primary use

Abroma augusta (L.) Willd. (fibre plants)
Abutilon indicum (L.) Sweet (medicinal and poisonous plants)
    Abutilon indicum G. Don
Acacia concinna (Willd.) A. DC. (ornamental plants)
    Acacia rugata (Lamk) Buch.-Ham. ex Benth.
Acacia farnesiana (L.) Willd. (essential-oil plants)
Acacia leucophloea (Roxburgh) Willd. (dye and tannin-producing plants)
Acacia nilotica (L.) Willd. ex Del. (dye and tannin-producing plants)
    Acacia arabica (Lamk) Willd.
Acacia pennata (L.) Willd. (medicinal and poisonous plants)
Acalypha indica L. (medicinal and poisonous plants)
Acalypha lanceolata Willd. (medicinal and poisonous plants)
    Acalypha boehmerioides Miquel
Acalypha wilkesiana Muell. Arg. (ornamental plants)
    Acalypha godseffiana Masters
    Acalypha hamiltoniana Bruant
Acanthophora spicifera (Vahl) Boergesen (lower plants)
    Acanthophora spicifera Boergesen f. *orientalis* J. Agardh
Aceratium oppositifolium DC. (edible fruits and nuts)
    Elaeocarpus oppositifolius Miquel
Achyranthes aspera L. (medicinal and poisonous plants)
Acronychia pedunculata (L.) Miquel (timber trees)
    Acronychia laurifolia Blume
Acrostichum aureum L. (lower plants)
Adenanthera pavonina L. (timber trees)
    Adenanthera bicolor Moon
    Adenanthera intermedia Merrill
    Adenanthera microsperma Teijsm. & Binnend.
    Adenanthera tamarindifolia Pierre
Adenostemma lavenia (L.) Kuntze (medicinal and poisonous plants)
Aegiceras corniculatus (L.) Blanco (timber trees)
Aegle marmelos (L.) Correa (edible fruits and nuts)
Aerva lanata (L.) A.L. Jussieu ex Schultes (medicinal and poisonous plants)
Agaricus campestris (L.) Fries (lower plants)
    Psalliota campestris (L.) Fries
Agaricus silvatica (Schaeffer) Fries (lower plants)
    Psalliota silvatica (Schaeffer) Fries
Agave cantala Roxburgh (fibre plants)
Agave sisalana Perrine (fibre plants)
Aglaonema pictum (Roxburgh) Kunth (ornamental plants)

Albizia procera (Roxburgh) Benth. (auxiliary plants in agriculture and forestry)
Alocasia macrorrhizos (L.) G. Don (plants mainly producing carbohydrates)
Alocasia indica Schott
Alpinia elegans (Presl) K. Schumann (medicinal and poisonous plants)
Languas elegans Burkill
Kolowratia elegans Presl
Alpinia galanga (L.) Willd. (spices)
Languas galanga Stuntz
Alpinia galanga (L.) Willd. var. *pyramidata* (Blume) K. Schumann (spices)
Languas pyramidata (Blume) Merrill
Alpinia zerumbet (Pers.) Burtt & Smith (ornamental plants)
Languas speciosa Small
Alternanthera sessilis (L.) A. DC. (medicinal and poisonous plants)
Alternanthera triandra Lamk
Alternanthera tenella Colla var. *versicolor* (Lem.) Veldk. (auxiliary plants in agriculture and forestry)
Alternanthera ficoidea Beauv. var. *bettzickiana* Backer
Alternanthera amoena Voss sensu Heyne
Altingia excelsa Noronha (timber trees)
Amanita manginiana Har. & Pat. (lower plants)
Amanita virginea Massee (lower plants)
Amaranthus caudatus L. (cereals)
Amaranthus hybridus L. ssp. *incurvatus* (Gren. & Godron) Brenan var. *paniculatus* (L.) Mansfeld (cereals)
Amaranthus paniculatus L.
Amaranthus spinosus L. (medicinal and poisonous plants)
Amomum acre Valeton (spices)
Amomum compactum Soland. ex Maton (spices)
Amomum cardamomum Willd.
Amomum kepulaga Sprague & Burkill ex Hooper
Amomum dealbatum Roxburgh (edible fruits and nuts)
Amorphophallus paeoniifolius (Dennst.) Nicolson (plants mainly producing carbohydrates)
Amorphophallus campanulatus Blume
Amorphophallus variabilis Blume (plants mainly producing carbohydrates)
Anacardium occidentale L. (edible fruits and nuts)
Anacolosa frutescens (Blume) Blume (edible fruits and nuts)
Anacolosa luzoniensis Merrill
Anacolosa heptandra Maing. ex Masters
Anadendrum microstachyum (Miquel) Backer & Alderw. (medicinal and poisonous plants)
Anadendrum montanum Schott
Ananas comosus (L.) Merrill (edible fruits and nuts)
Anethum graveolens L. (spices)
Angiopteris amboinensis de Vriese (lower plants)
Annona muricata L. (edible fruits and nuts)
Anoectochilus albo-lineatus Par. & H.G. Reichenbach (ornamental plants)
Anoectochilus geniculatus Ridley (ornamental plants)

Anoectochilus reinwardtii Blume (ornamental plants)
Antidesma bunius (L.) Sprengel (edible fruits and nuts)
    Antidesma dallachyanum Baillon
    Antidesma rumphii Tulasne
Antidesma ghaesembilla Gaertner (edible fruits and nuts)
Antigonon leptopus Hook. & Arnott (ornamental plants)
Arachis hypogaea L. (pulses)
Archidendron kunstleri (Prain) Nielsen (timber trees)
    Pithecellobium kunstleri Prain
Archidendron microcarpum (Benth.) Nielsen (timber trees)
    Pithecellobium bubalinum auct. non (Jack) Benth.
    Pithecellobium microcarpum Benth.
Arcypteris irregularis (Presl) Holtt. (lower plants)
    Dictyopteris irregularis Presl
    Dictyopteris difformis Moore
Ardisia crenata (Sims) Little (edible fruits and nuts)
    Ardisia crispa (Thunberg ex Murray) A. DC.
Ardisia squamulosa Presl (spices)
    Ardisia boissieri A. DC.
Areca caliso Beccari (stimulants)
Areca catechu L. (stimulants)
Areca latiloba Ridley (stimulants)
    Areca pumila Blume
Areca triandra Roxburgh (stimulants)
    Areca borneensis Beccari
Arenga pinnata (Wurmb) Merrill (plants mainly producing carbohydrates)
Arenga undulatifolia Beccari (plants mainly producing carbohydrates)
    Arenga ambong Beccari.
Arenga westerhoutii Griffith (plants mainly producing carbohydrates)
Armoracia rusticana P. Gaertner, Mey. & Scherb. (spices)
    Cochlearia armoracea L.
Artemisia vulgaris L. (medicinal and poisonous plants)
Artocarpus altilis (Parkinson) Fosberg (edible fruits and nuts)
    Artocarpus communis J.R. & G. Forster
    Artocarpus camansi Blanco
Artocarpus gomeziana Wallich ex Trécul (timber trees)
Artocarpus heterophyllus Lamk (edible fruits and nuts)
Artocarpus integer (Thunberg) Merrill (edible fruits and nuts)
    Artocarpus champeden (Loureiro) Stokes
Artocarpus odoratissimus Blanco (edible fruits and nuts)
Asplenium nidus L. (lower plants)
    Neottopteris nidus J. Smith
Asystasia gangetica (L.) T. Anderson (forages)
    Asystasia coromandeliana Nees
Auricularia auricula-judae (Bulliard) Wettst. (lower plants)
Auricularia auricularis Lloyd (lower plants)
Auricularia cornea (Ehrenb. ex Fr.) Ehrenb. ex Endl. (lower plants)
Auricularia delicata (Fries) Hennings (lower plants)
    Auricularia moellerii Lloyd

Auricularia fuscosuccinea (Mont.) Farlow (lower plants)
Auricularia polytricha (Montagne) Saccardo (lower plants)
Auricularia porphyrea Leveille (lower plants)
Auricularia tenuis Fries (lower plants)
Averrhoa carambola L. (edible fruits and nuts)
Avicennia officinalis L. (timber trees)
Azadirachta indica Adr. Juss. (medicinal and poisonous plants)
  Melia indica Brandis
Baccaurea ramiflora Loureiro (edible fruits and nuts)
  Baccaurea sapida Muell. Arg.
  Baccaurea wrayi King
Bacopa monnieri (L.) Wettst. (medicinal and poisonous plants)
  Herpestis monnieria (L.) Kunth
Bactris gasipaes Kunth (edible fruits and nuts)
  Bactris utilis Benth. & Hook.f. ex Hemsley
Bambusa balcooa Roxb. (bamboos)
Bambusa bambos (L.) Voss (bamboos)
  Bambusa arundinacea (Retz.) Willd.
Bambusa blumeana Schultes (bamboos)
  Bambusa arundo Blanco
  Bambusa pungens Blanco
  Bambusa spinosa Blume ex Nees
Bambusa multiplex (Lour.) Raeuschel (bamboos)
Bambusa oldhamii Munro (bamboos)
Bambusa vulgaris Schrader ex Wendland (bamboos)
Barringtonia acutangula (L.) Gaertner (timber trees)
  Barringtonia edaphocarpa Gagnepain
  Barringtonia spicata Blume
Barringtonia asiatica (L.) Kurz (medicinal and poisonous plants)
Barringtonia fusiformis King (timber trees)
Barringtonia macrocarpa Hassk. (medicinal and poisonous plants)
  Barringtonia insignis (Blume) Miquel
Barringtonia racemosa (L.) Sprengel (medicinal and poisonous plants)
  Barringtonia racemosa (L.) Roxburgh
Bauhinia lingua DC. (medicinal and poisonous plants)
Bauhinia malabarica Roxburgh (timber trees)
Bauhinia tomentosa L. (ornamental plants)
Bauhinia variegata L. (ornamental plants)
Bidens biternata (Loureiro) Merrill & Sherff (medicinal and poisonous plants)
  Bidens chinensis Willd.
Bidens pilosa L. var. *radiata* Schultz-Bip. (medicinal and poisonous plants)
  Bidens pilosus L. var. *albus* Schultz-Bip.
Blechnum orientale L. (lower plants)
Blumea balsamifera (L.) DC. (essential-oil plants)
Blumea chinensis DC. (variously misapplied to *Blumea riparia* (Blume) DC., *Blumea bullata* Koster or *Blumea balsamifera* (L.) DC.) (medicinal and poisonous plants)
Blumea lacera (Burm.f.) DC. (medicinal and poisonous plants)
Boerhaavia diffusa L. (medicinal and poisonous plants)

Boesenbergia rotunda (L.) Mansf. (spices)
  Boesenbergia pandurata (Roxb.) Schlecht.
  Gastrochilus panduratum Ridley
Boletus bovinus (L.) Fries (lower plants)
Boletus subtomentosus (L.) Fries (lower plants)
Bombax ceiba L. (timber trees)
  Gossampinus heptaphylla Bakh.
  Bombax malabaricum DC.
Bombax valetonii Hochr. (timber trees)
  Bombax insigne Wallich
  Bombax larutense Ridley
Borassus flabellifer L. (plants mainly producing carbohydrates)
Borreria hispida (L.) K. Schumann (medicinal and poisonous plants)
Bouea macrophylla Griffith (edible fruits and nuts)
Breynia racemosa (Blume) Muell. Arg. (medicinal and poisonous plants)
  Breynia reclinata Hook.f.
Breynia vitis-idaea (Burm.f.) C.E.C. Fischer (medicinal and poisonous plants)
  Breynia rhamnoides Muell. Arg.
Broussonetia papyrifera (L.) Ventenat (fibre plants)
Bruguiera cylindrica (L.) Blume (auxiliary plants in agriculture and forestry)
  Bruguiera caryophylloides Blume
Bruguiera gymnorhiza (L.) Savigny (dye and tannin-producing plants)
  Bruguiera conjugata Merrill
Bruguiera parviflora (Roxburgh) Wight & Arnott ex Griffith (timber trees)
Bruguiera sexangula (Loureiro) Poiret (auxiliary plants in agriculture and forestry)
  Bruguiera eriopetala Wight & Arnott ex Arnott
Cajanus cajan (L.) Millspaugh (pulses)
  Cajanus indicus Sprengel
Calamus burckianus Beccari (rattans)
Calamus castaneus Beccari (rattans)
Calamus egregius Burret (rattans)
Calamus javensis Blume (rattans)
  Calamus filiformis Beccari
Calamus merrillii Beccari (rattans)
  Calamus maximus Merrill
Calamus mindorensis Beccari (rattans)
Calamus muricatus Beccari (rattans)
Calamus ornatus Blume (rattans)
Calamus paspalanthus Beccari (rattans)
Calamus simplicifolius Wei (rattans)
Calamus subinermis H. Wendl. ex Beccari (rattans)
Calotropis gigantea (L.) Dryander (medicinal and poisonous plants)
Calvatia bovista (L.) van Overeem (lower plants)
  Lycoperdon bovista Fries
Calvatia kakavù (Zippel) van Overeem (lower plants)
Canarium ovatum Engl. (edible fruits and nuts)
Canavalia ensiformis (L.) DC. (forages)
Canavalia maritima (Aublet) du Petit-Thouars (auxiliary plants in agriculture

and forestry)
Canavalia rosea (Swartz) DC.
Canna edulis Ker (plants mainly producing carbohydrates)
Canthium horridum Blume (ornamental plants)
Plectronia horrida Schumann
Capparis spinosa L. var. *mariana* (Jacq.) K. Schumann (spices)
Capparis cordifolia Lamk
Capparis mariana Jacq.
Capparis zeylanica L. (edible fruits and nuts)
Capparis horrida L.f.
Cardiospermum halicacabum L. (medicinal and poisonous plants)
Carica papaya L. (edible fruits and nuts)
Carica pubescens Lenné & K. Koch (edible fruits and nuts)
Carica candamarcensis Hook.f.
Carthamus tinctorius L. (vegetable oils and fats)
Caryota cumingii Loddiges ex Martius (fibre plants)
Caryota majestica Linden (ornamental plants)
Caryota maxima Blume (fibre plants)
Caryota aequatorialis Ridl.
Caryota merrillii Beccari (fibre plants)
Caryota mitis Loureiro (fibre plants)
Caryota obtusa Griffith (fibre plants)
Caryota rumphiana Martius (timber trees)
Caryota urens L. (fibre plants)
Cassia alata L. (medicinal and poisonous plants)
Cassia auriculata L. (dye and tannin-producing plants)
Cassia floribunda Cavanilles (ornamental plants)
Cassia laevigata Willd.
Cassia garrettiana Craib (ornamental plants)
Cassia hirsuta L. (auxiliary plants in agriculture and forestry)
Cassia nodosa Buch.-Ham. ex Roxburgh (timber trees)
Cassia occidentalis L. (stimulants)
Cassia siamea Lamk (auxiliary plants in agriculture and forestry)
Cassia sophera L. (medicinal and poisonous plants)
Cassia surattensis Burm. f. (medicinal and poisonous plants)
Cassia timoriensis DC. (timber trees)
Cassia tora L. (medicinal and poisonous plants)
Castanopsis inermis (Lindley ex Wallich) Benth. & Hook. (edible fruits and nuts)
Castanea sumatrana (Miquel) Oerst.
Castanopsis rhamnifolia (Miquel) A. DC. (timber trees)
Castanea rhamnifolia Kurz
Catenella impudica (Mont.) Grev. (lower plants)
Catunaregam spinosa (Thunberg) Tirvengadum (medicinal and poisonous plants)
Randia dumetorum Lamk
Caulerpa racemosa (Forsskal) J. Agardh (lower plants)
Caulerpa clavifera Agardh
Caulerpa racemosa (Forsskal) J. Agardh var. ? (lower plants)

Caulerpa racemosa J. Agardh var. *clavifera* Weber van Bosse
Caulerpa racemosa (Forsskal) J. Agardh var. *laetevirens* (Mont.) Weber van Bosse (lower plants)
Caulerpa laetevirens Weber van Bosse
Caulerpa racemosa (Forsskal) J. Agardh var. *peltata* (Lamouroux) Eubank (lower plants)
Caulerpa peltata Lamouroux var. *macrodisca* Weber van Bosse
Caulerpa serrulata (Forsskal) J. Agardh (lower plants)
Caulerpa freycinetii Agardh
Cayratia trifolia (L.) Domin (medicinal and poisonous plants)
Vitis trifolia L.
Cecropia peltata L. (medicinal and poisonous plants)
Ceiba pentandra (L.) Gaertner (fibre plants)
Celosia argentea L. (ornamental plants)
Celosia cristata L.
Celtis luzonica Warb. (timber trees)
Centella asiatica (L.) Urb. (medicinal and poisonous plants)
Hydrocotyle asiatica L.
Cephalostachyum mindorense Gamble (bamboos)
Ceratopteris thalictroides (L.) Brongn. (lower plants)
Cerbera manghas L. (medicinal and poisonous plants)
Chaetomorpha crassa (C. Agardh) Kuetzing (lower plants)
Chenopodium album L. ssp. amaranticolor Coste & Reyn. (cereals)
Chilocarpus denudatus Blume (medicinal and poisonous plants)
Chloranthus erectus (Buch.-Ham.) Verdc. (stimulants)
Chloranthus officinalis Blume
Chnoospora pacifica J. Agardh (lower plants)
Chnoospora fastigiata J. Agardh
Cibotium barometz (L.) J. Sm. (lower plants)
Cicer arietinum L. (pulses)
Cissus quadrangularis L. (medicinal and poisonous plants)
Vitis quadrangularis Wallich
Cladoderris elegans (Junghuhn) Fries (lower plants)
Claoxylon indicum (Reinw. ex Blume) Hassk. (spices)
Claoxylon polot Merrill
Clausena excavata Burm.f. (medicinal and poisonous plants)
Cleome speciosa Raf. (ornamental plants)
Cleome speciosissima Deppe ex Lindley
Gynandropsis speciosa DC.
Cleome viscosa L. (medicinal and poisonous plants)
Polanisia viscosa DC.
Cleome icosandra L.
Clerodendrum minahassae Teijsm. & Binnend. (ornamental plants)
Clerodendrum serratum (L.) Moon (medicinal and poisonous plants)
Clitocybe hypocalamus van Overeem (lower plants)
Clitocybe nebularis Batsch (lower plants)
Clitoria ternatea L. (forages)
Cnestis palala (Loureiro) Merrill (medicinal and poisonous plants)
Cochlospermum religiosum (L.) Alston (plants producing exudates)

Cochlospermum gossypium DC.
Cocos nucifera L. (vegetable oils and fats)
Codiaeum variegatum (L.) Blume (ornamental plants)
Codium tenue (Kuetzing) Kuetzing (lower plants)
Codium tomentosum Stackh. (lower plants)
Colocasia esculenta (L.) Schott (plants mainly producing carbohydrates)
Colocasia gigantea (Blume) Hook.f. (spices)
Colubrina asiatica (L.) Brongn. (timber trees)
Commelina diffusa Burm.f. (forages)
Commelina nudiflora auct. non L.
Conchomyces verrucisporus van Overeem (lower plants)
Conyza sumatrensis (Retzius) E. Walker (medicinal and poisonous plants)
Erigeron sumatrensis Retzius
Erigeron linifolius Willd. (misapplied to *Conyza sumatrensis* (Retzius) E. Walker)
Coprinus atramentarius (Bulliard) Fries (lower plants)
Coprinus comatus (Fl. Dan.) Fries (lower plants)
Coprinus macrorhizus (Persoon) Rea (lower plants)
Coprinus microsporus Berkeley & Broome (lower plants)
Corchorus aestuans L. (fibre plants)
Corchorus acutangulus Lamk
Corchorus capsularis L. (fibre plants)
Corchorus olitorius L. (fibre plants)
Cordia dichotoma Forster f. (medicinal and poisonous plants)
Cordia obliqua Willd.
Cordyline fruticosa (L.) A. Chevalier (ornamental plants)
Cordyline terminalis (L.) Kunth
Dracaena aurantiaca Wallich
Dracaena congesta Ridley
Dracaena graminifolia Wallich
Coriandrum sativum L. (spices)
Cortinellus berkeleyanus Seiya Ito & Sanshi Imai (lower plants)
Corypha laevis A. Chevalier (fibre plants)
Corypha umbraculifera L. (fibre plants)
Corypha utan Lamk (fibre plants)
Corypha elata Roxburgh
Cosmos sulphureus Cav. (ornamental plants)
Craterellus cornucopioides (L.) Fries (lower plants)
Cratoxylum formosum (Jack) Dyer (timber trees)
Crepidopus djamor (Fries) van Overeem (lower plants)
Crepidopus fissilis (Leveille) van Overeem (lower plants)
Crepidotus edulis van Overeem (lower plants)
Crepidotus ridleyi Massee (lower plants)
Crotalaria pallida Aiton (auxiliary plants in agriculture and forestry)
Crotalaria mucronata Desv.
Crotalaria striata DC.
Crotalaria quinquefolia L. (auxiliary plants in agriculture and forestry)
Crotalaria retusa L. (auxiliary plants in agriculture and forestry)
Crypteronia paniculata Blume (timber trees)

Cubilia cubili (Blanco) Adelb. (timber trees)
 Cubilia blancoi Blume
Curcuma aurantiaca Van Zyp (medicinal and poisonous plants)
Curcuma longa L. (spices)
 Curcuma domestica Valeton
Curcuma purpurascens Blume (medicinal and poisonous plants)
Curcuma xanthorrhiza Roxburgh (plants mainly producing carbohydrates)
Curcuma zeodaria (Christm.) Roscoe (medicinal and poisonous plants)
Cuscuta australis R. Br. (medicinal and poisonous plants)
Cyamopsis tetragonoloba (L.) Taubert (auxiliary plants in agriculture and forestry)
 Cyamopsis psoralioides DC.
Cyathea amboinensis (v.A.v.R.) Merrill (lower plants)
 Alsophila amboinensis v.A.v.R.
Cyathea contaminans (Wallich ex Hook.) Copel. (lower plants)
 Alsophila glauca (Blume) J. Sm.
Cyathea junghuhniana (Kunze) Copel. (lower plants)
 Hemitelia latebrosa (Wall. ex Hook) Mett.
Cyathea moluccana R. Br. (lower plants)
Cycas rumphii Miquel (edible fruits and nuts)
 Cycas circinalis L.
Cyclea barbata Miers (medicinal and poisonous plants)
Cynometra cauliflora L. (edible fruits and nuts)
Cyphomandra betacea (Cav.) Sendtner (edible fruits and nuts)
Cyrtosperma chamissonis (Schott) Merrill (plants mainly producing carbohydrates)
 Cyrtosperma edule Schott
Cyrtosperma merkusii (Schott) Merrill (plants mainly producing carbohydrates)
Daemonorops fissa (Miquel) Blume (rattans)
Daemonorops longipes (Griffith) Martius (rattans)
Daemonorops longispatha Beccari (rattans)
Daemonorops margaritae (Hance) Beccari (rattans)
Daemonorops melanochaetes Blume (rattans)
Daemonorops mollis (Blanco) Merrill (rattans)
 Calamus mollis Blanco
Daemonorops oblonga Blume (rattans)
Daemonorops palembanica Blume (rattans)
Daemonorops periacantha Miquel (rattans)
Daemonorops rubra (Reinw. ex Blume) Blume (rattans)
Daemonorops scapigera Beccari (rattans)
Daemonorops sparsiflora Beccari (rattans)
Decaspermum fruticosum J.R. & G. Forster (timber trees)
Deeringia amaranthoides (Lamk) Merrill (medicinal and poisonous plants)
Dendrocalamus asper (Schultes f.) Backer ex Heyne (bamboos)
 Gigantochloa aspera (Schultes f.) Kurz
Dendrocalamus brandisii (Munro) Kurz (bamboos)
Dendrocalamus giganteus Munro (bamboos)
Dendrocalamus hamiltonii Nees & Arnott (bamboos)

Dendrocalamus latiflorus Munro (bamboos)
Dendrocalamus longispathus Kurz (bamboos)
Dendrocalamus membranaceus Munro (bamboos)
Dendrocnide stimulans (L.f.) Chew (medicinal and poisonous plants)
  Laportea stimulans Miquel
Desmodium repandum (Vahl) DC. (medicinal and poisonous plants)
  Desmodium scalpe DC.
Detarium senegalense J.F. Gmelin (timber trees)
Dichapetalum timoriense (DC.) Boerl. (fibre plants)
Dictyota dichotoma (Hudson) Lamouroux (lower plants)
  Dictyota apiculata J. Agardh
Dillenia indica L. (timber trees)
Dillenia philippinensis Rolfe (timber trees)
Dillenia reifferscheidia Villar (edible fruits and nuts)
Dinochloa luconiae (Munro) Merrill (bamboos)
Dinochloa pubiramea Gamble (bamboos)
Dioscorea alata L. (plants mainly producing carbohydrates)
Dioscorea bulbifera L. (plants mainly producing carbohydrates)
Dioscorea divaricata Blanco (plants mainly producing carbohydrates)
Dioscorea esculenta (Loureiro) Burkill (plants mainly producing carbohydrates)
  Dioscorea aculeata L.
Dioscorea hispida Dennstedt (plants mainly producing carbohydrates)
Dioscorea luzonensis Schauer (plants mainly producing carbohydrates)
  Dioscorea pentaphylla L. (plants mainly producing carbohydrates)
Diplazium asperum Blume (lower plants)
Diplazium esculentum (Retzius) Swartz (lower plants)
  Athyrium esculentum (Retzius) Copel.
Diplazium proliferum Thouars (lower plants)
Dischidia nummularia R. Br. (medicinal and poisonous plants)
  Dischidia gaudichaudii J. Decaisne
Dolichandrone spathacea (L.f.) K. Schumann (timber trees)
Dracaena angustifolia Roxburgh (medicinal and poisonous plants)
  Pleomele angustifolia N.E. Brown
Dracontomelon dao (Blanco) Merrill & Rolfe (edible fruits and nuts)
  Dracontomelon edule (Blanco) Skeels
  Dracontomelon mangiferum (Blume) Blume
  Dracontomelon sylvestre Blume
Drynaria sparsisora Moore (lower plants)
Dryobalanops oblongifolia Dyer (timber trees)
Durio zibethinus Murr. (edible fruits and nuts)
Dysoxylum alliaceum Blume (essential-oil plants)
  Dysoxylum costulatum Miquel
  Dysoxylum euphlebium Merrill
  Dysoxylum thyrsoideum Griffith
Echinochloa colona (L.) Link (forages)
  Panicum colonum L.
Echinochloa crus-galli (L.) P. Beauv. (forages)
  Panicum crus-galli L.
Eclipta alba (L.) Hassk. (dye and tannin-producing plants)

Eclipta prostrata (L.) L.
Eichhornia crassipes (Martius) Solms (auxiliary plants in agriculture and forestry)
Pontederia crassipes Martius
Eichhornia speciosa Kunth
Eleocharis dulcis (Burm.f.) Henschel (plants mainly producing carbohydrates)
Heleocharis plantaginoidea W.F. Wight
Eleocharis tuberosa Schultes
Elettariopsis sumatrana Valeton (medicinal and poisonous plants)
Eleusine indica (L.) Gaertner f. *coracana* (L.) Hook.f. ex Backer (cereals)
Eleusine coracana Gaertner
Embelia philippinensis A. DC. (spices)
Embelia ribes Burm.f. (medicinal and poisonous plants)
Ensete glaucum (Roxburgh) Cheesman (ornamental plants)
Musa glauca Roxburgh
Entada phaseoloides (L.) Merrill (medicinal and poisonous plants)
Entada spiralis Ridley (medicinal and poisonous plants)
Enteromorpha compressa (L.) Nees (lower plants)
Enteromorpha intestinalis (L.) Nees (lower plants)
Enteromorpha prolifera (Mueller) J. Agardh (lower plants)
Enteromorpha tubulosa Kuetzing
Entoloma clypeatum Fries (lower plants)
Entoloma microcarpum Berkeley & Broome (lower plants)
Erianthus arundinaceus (Retzius) Jeswiet (fibre plants)
Saccharum arundinaceum Retzius
Eryngium foetidum L. (spices)
Erythrina fusca Loureiro (auxiliary plants in agriculture and forestry)
Erythrina subumbrans (Hassk.) Merrill (auxiliary plants in agriculture and forestry)
Erythrina lithosperma Miquel
Erythrina variegata L. (auxiliary plants in agriculture and forestry)
Erythrina variegata L. var. *orientalis* (L.) Merrill
Erythrina indica Lamk
Etlingera elatior (Jack) R.M. Smith (spices)
Nicolaia speciosa Horan.
Phaeomeria speciosa Koord.
Etlingera hemisphaerica (Blume) R.M. Smith (spices)
Nicolaia atropurpurea Valeton
Phaeomeria atropurpurea K. Schumann
Etlingera littoralis (Koenig) Giseke (edible fruits and nuts)
Achasma megalocheilos Griffith
Eucheuma denticulatum (Burman) Coll. & Herv. (lower plants)
Eucheuma spinosum J. Agardh
Eucheuma serra (J. Agardh) J. Agardh (lower plants)
Eugeissona insignis Beccari (fibre plants)
Eugeissona utilis Beccari (plants mainly producing carbohydrates)
Euodia lucida Miquel (medicinal and poisonous plants)
Euphorbia antiquorum L. (medicinal and poisonous plants)
Euphorbia barnhartii Croizat (medicinal and poisonous plants)

Euphorbia trigona Roxburgh non Miller
Euphorbia hirta L. (medicinal and poisonous plants)
Euphorbia pilulifera L.
Euphorbia neriifolia L. (medicinal and poisonous plants)
Euphorbia pulcherrima Willd. ex Klotzsch (ornamental plants)
Euterpe oleracea Martius (edible fruits and nuts)
Excoecaria indica (Willd.) Muell. Arg. (dye and tannin-producing plants)
Sapium indicum Willd.
Favolus spathulatus (Junghuhn) Bresadola (lower plants)
Ficus altissima Blume (fibre plants)
Ficus annulata Blume (timber trees)
Ficus callosa Willd. (timber trees)
Ficus elastica Roxburgh ex Hornem. (plants producing exudates)
Ficus hirta Vahl (forages)
Ficus lepicarpa Blume (edible fruits and nuts)
Ficus montana Burm.f. (edible fruits and nuts)
Ficus quercifolia Roxburgh
Ficus nota (Blanco) Merrill (edible fruits and nuts)
Ficus racemosa L. (edible fruits and nuts)
Ficus glomerata Roxburgh
Ficus recurva Blume (stimulants)
Ficus religiosa L. (medicinal and poisonous plants)
Ficus rumphii Blume (medicinal and poisonous plants)
Ficus trematocarpa Miquel (spices)
Ficus ulmifolia Lamk (edible fruits and nuts)
Ficus variegata Blume (plants producing exudates)
Ficus virens Aiton (fibre plants)
Ficus infectoria Roxburgh
Ficus lacor Buch.-Ham.
Ficus virens Aiton var. *glabella* (Blume) Corner (plants producing exudates)
Ficus glabella Blume
Ficus virgata Reinw. ex Blume (spices)
Ficus trematocarpa Miquel
Ficus wassa Roxburgh (medicinal and poisonous plants)
Fistulina hepatica (Hudson) Fries (lower plants)
Flacourtia rukam Zollinger & Moritzi (edible fruits and nuts)
Flacourtia euphlebia Merrill
Foeniculum vulgare Miller (spices)
Freycinetia funicularis (Lamk) Merrill (ornamental plants)
Galiella javanica (Rehm) Nannf. & Korf (lower plants)
Sarcosma javanica Rehm
Sarcosma decaryi Pat.
Sarcosma novoguineense Ramsb.
Garcinia amboinensis Sprengel (stimulants)
Garcinia atroviridis Griffith ex T. Anderson (edible fruits and nuts)
Garcinia cochinchinensis (Loureiro) Choisy (edible fruits and nuts)
Garcinia indica (Thouin) Choisy (vegetable oils and fats)
Garcinia microstigma Kurz
Garcinia parvifolia (Miquel) Miquel (timber trees)

Garcinia dioica Blume
Garcinia sizygiifolia Pierre (edible fruits and nuts)
Gelidiella acerosa (Forsskal) Feldmann & Hamel (lower plants)
Gelidiopsis rigida (Vahl) Weber-van Bosse
Gelidium regidum (Vahl) Greville
Gigantochloa albociliata Kurz (bamboos)
Gigantochloa apus (Schultes & Schultes) Kurz (bamboos)
Gigantochloa kurzii Gamble
Gigantochloa atroviolacea Widjaja (bamboos)
Gigantochloa atter (Hassk.) Kurz (bamboos)
Gigantochloa balui K.M. Wong (bamboos)
Gigantochloa hasskarliana (Kurz) Backer ex Heyne (bamboos)
Oxytenanthera nigrociliata (Buse) Munro
Gigantochloa levis (Blanco) Merrill (bamboos)
Gigantochloa manggong Widjaja (bamboos)
Gigantochloa nigrociliata (Buse) Kurz (bamboos)
Gigantochloa pruriens Widjaja (bamboos)
Gigantochloa pseudoarundinacea (Steud.) Widjaja (bamboos)
Gigantochloa verticillata (Willd.) Munro
Gigantochloa robusta Kurz (bamboos)
Gigantochloa thoii K.M. Wong (bamboos)
Gigantochloa wrayi Gamble (bamboos)
Gigartina spp. (lower plants)
Gliricidia sepium (Jacq.) Kunth ex Walp. (forages/auxiliary plants in agriculture and forestry)
Glochidion borneense (Muell. Arg.) Boerl. (timber trees)
Glochidion microbotrys Hook.f.
Glochidion rubrum Blume (medicinal and poisonous plants)
Gluta velutina Blume (timber trees)
Glycine max (L.) Merrill (pulses)
Glycosmis pentaphylla (Retzius) DC. (medicinal and poisonous plants)
Glycosmis platyphylla Merrill (medicinal and poisonous plants)
Gnetum costatum K. Schumann (edible fruits and nuts)
Gnetum gnemon L. (edible fruits and nuts)
Gnetum latifolium Blume (edible fruits and nuts)
Gnetum indicum (Loureiro) Merrill
Gnetum funiculare Blume
Gomphrena globosa L. (ornamental plants)
Gossypium barbadense L. var. *acuminatum* (Roxburgh) Masters (fibre plants)
Gossypium acuminatum Roxburgh
Gossypium brasiliense Macfad.
Gossypium vitifolium Lamk
Gossypium hirsutum L. var. *taitense* (Parlatore) Roberty (fibre plants)
Gossypium purpurascens (non Poiret) Watt
Gossypium javanicum Blume
Gracilaria salicornia (C. Agardh) Dawson (lower plants)
Corallopsis salicornia Greville var. *minor* Sond.
Corallopsis minor J. Agardh
Graptophyllum pictum (L.) Griffith (ornamental plants)

Grewia multiflora Jussieu (fibre plants)
Gronophyllum microcarpum Scheffer (timber trees)
Gymnopetalum chinense (Loureiro) Merrill (edible fruits and nuts)
    Gymnopetalum cochinchinense (Loureiro) Kurz
    Gymnopetalum quinquelobum Miquel
    Gymnopetalum leucostictum Miquel
Gymnopus albuminosus (Berkeley) van Overeem (lower plants)
    Collybia albuminosa Petch
Gymnopus microcarpus (Berkeley & Broome) van Overeem (lower plants)
    Collybia microcarpa von Hohnel
Gynura procumbens (Loureiro) Merrill (medicinal and poisonous plants)
    Gynura sarmentosa DC.
Halòpegia blumei (Koern.) K. Schumann (plants mainly producing carbohydrates)
Halymenia amoena Bory (lower plants)
Halymenia formosa Harvey ex Kuetzing (lower plants)
Hedyotis auricularia L. (medicinal and poisonous plants)
Helianthus annuus L. (vegetable oils and fats)
Helianthus tuberosus L. (plants mainly producing carbohydrates)
Helicia serrata (R. Br.) Blume (timber trees)
Helminthostachys zeylanica (L.) Hook. (lower plants)
Hemerocallis fulva L. (ornamental plants)
Hemerocallis lilio-asphodelus L. (ornamental plants)
    Hemerocallis flava L.
Hemerocallis minor Miller (ornamental plants)
Heterospathe elata Scheffer (ornamental plants)
Heterospathe negrosensis Beccari (ornamental plants)
Heterospathe philippinensis Beccari (ornamental plants)
Heterospathe sibuyanensis Beccari (ornamental plants)
Hevea brasiliensis (Willd. ex A. Jussieu) Muell. Arg. (plants producing exudates)
Hibiscus cannabinus L. (fibre plants)
Hibiscus radiatus Cav. (medicinal and poisonous plants)
    Hibiscus radiatus Willd. sensu Burkill
Hibiscus rosa-sinensis L. (ornamental plants)
Hibiscus tiliaceus L. (fibre plants)
Homonoia riparia Loureiro (auxiliary plants in agriculture and forestry)
Hornstedtia scottiana (F. v. Muell.) K. Schumann (edible fruits and nuts)
    Hornstedtia lycostoma K. Schumann
Hydnum elatum Massee (lower plants)
Hydnum fragile Petch (lower plants)
Hydrocotyle javanica J.P. Ponten ex Thunberg (medicinal and poisonous plants)
Hydrolea zeylanica (L.) Vahl (medicinal and poisonous plants)
Hygrophila ringens (L.) Steudel (medicinal and poisonous plants)
    Hygrophila angustifolia R. Br.
    Hygrophila phlomoides Nees
    Hygrophila quadrivalvis Nees
Hymenomarasmius venosus (Hennings & Nyman) van Overeem (lower plants)

Hypnea cenomyce J. Agardh (lower plants)
Hypnea cervicornis J. Agardh (lower plants)
Hyptis brevipes Poit. (medicinal and poisonous plants)
Iguanura wallichiana (Wallich ex Martius) J.D. Hooker (stimulants)
  Iguanura geonomiformis Martius
Impatiens balsamina L. (dye and tannin-producing plants)
Imperata conferta (Presl) Ohwi (fibre plants)
  Imperata contracta Hitchc.
  Imperata exaltata Brongn. (misapplied to *Imperata conferta* (Presl) Ohwi)
Imperata cylindrica (L.) Raeuschel (forages)
Inocybe cutifracta Petch (lower plants)
Ipomoea alba L. (ornamental plants)
  Calonyction bona-nox Bojer
  Calonyction aculeatum House
Ipomoea batatas (L.) Lamk (plants mainly producing carbohydrates)
Ipomoea quamoclit L. (ornamental plants)
  Quamoclit pinnata Bojer
Ipomoea rumphii Miquel (medicinal and poisonous plants)
Ipomoea triloba L. (medicinal and poisonous plants)
Isachne albens Trinius (forages)
Isachne globosa (Thunberg ex Murray) O. Kuntze (forages)
Ixora coccinea L. (medicinal and poisonous plants)
Jatropha curcas L. (medicinal and poisonous plants)
Jatropha multifida L. (medicinal and poisonous plants)
Justicia procumbens L. (medicinal and poisonous plants)
  Rostellaria procumbens (L.) Nees
Kaempferia galanga L. (medicinal and poisonous plants)
Kaempferia rotunda L. (medicinal and poisonous plants)
Kleinhovia hospita L. (auxiliary plants in agriculture and forestry)
Lablab purpureus (L.) Sweet (pulses)
  Dolichos lablab L.
Laccaria laccata Scop. (lower plants)
  Clitocybe laccata Scop.
Lactarius spp. (lower plants)
Laetiporus flos-musae van Overeem (lower plants)
Laetiporus miniatus (Junghuhn) van Overeem (lower plants)
Laminaria saccharina Lamouroux (lower plants)
Lannea coromandelica (Houtt.) Merrill (ornamental plants)
  Lannea grandis (Dennst.) Engl.
Laportea interrupta (L.) Chew (medicinal and poisonous plants)
  Fleurya interrupta Gaudich.
Lathyrus sativus L. (pulses)
Laurencia botryoides (Turner) Gaillon (lower plants)
Leea aequata L. (medicinal and poisonous plants)
Leea guineensis G. Don (medicinal and poisonous plants)
  Leea manillensis Walp.
Lens culinaris Medikus (pulses)
  Lens esculenta Moench
Lentinus connatus Berkeley (lower plants)

Lentinus edodes (Berkeley) Sing. (lower plants)
    Cortinellus shiitake (Schroeter) Hennings
Lentinus sajor caju Fries (lower plants)
Lentinus subnudus Berkeley (lower plants)
Lepidium sativum L. (medicinal and poisonous plants)
Lepiota procera Scop. (lower plants)
Lepisanthes rubiginosa (Roxburgh) Leenh. (timber trees)
    Erioglossum rubiginosum Blume
Leucaena leucocephala (Lamk) de Wit (forages/auxiliary plants in agriculture and forestry)
    Leucaena glauca (Willd.) Benth.
Leucas lavandulifolia J.E. Smith (medicinal and poisonous plants)
    Leucas linifolia (Roth) Sprengel
Leucas zeylanica (L.) R. Br. (medicinal and poisonous plants)
Licuala acutifida Martius (timber trees)
Licuala kunstleri Beccari (timber trees)
Licuala paludosa Griffith (timber trees)
Licuala spinosa Thunberg (timber trees)
Licuala triphylla Griffith (timber trees)
Limnophila aromatica (Lamk) Merrill (medicinal and poisonous plants)
Limnophila erecta Benth. (medicinal and poisonous plants)
Limnophila rugosa (Roth) Merrill (spices)
Lithocarpus celebicus (Miquel) Rehder (timber trees)
    Quercus celebica Miquel
    Quercus companoana Vidal
Livistona merrillii Beccari (timber trees)
Livistona robinsoniana Beccari (timber trees)
Livistona rotundifolia (Lamk) Martius (timber trees)
Livistona saribus (Loureiro) Merrill ex Chevalier (fibre plants)
Lycoperdon fuligineum Berkeley & Curtis (lower plants)
Lycoperdon piriforme Schaeffer (lower plants)
Lycoperdon pratense Persoon (lower plants)
Lygodium circinnatum (Burm.f.) Swartz (lower plants)
    Lygodium pedatum (Burm.f.) Swartz
Lygodium microphyllum (Cav.) R. Br. (lower plants)
    Lygodium scandens (L.) Swartz
Maclura cochinchinensis (Loureiro) Corner (dye and tannin-producing plants)
    Cudrania javanensis Trécul
Macrolenes muscosa (Blume) Bakh.f. (edible fruits and nuts)
    Marumia muscosa Blume
Malus domestica Borkh. (edible fruits and nuts)
    Malus sylvestris Miller sensu auct. mult.
    Pyrus malus L. p.p.
Mangifera altissima Blanco (edible fruits and nuts)
    Mangifera rumphii Pierre
Mangifera foetida Loureiro (edible fruits and nuts)
Mangifera indica L. (edible fruits and nuts)
Mangifera kemanga Blume (edible fruits and nuts)
Mangifera laurina Blume (edible fruits and nuts)

Mangifera pajang Kostermans (edible fruits and nuts)
Mangifera pentandra Hooker f. (edible fruits and nuts)
Manihot esculenta Crantz (plants mainly producing carbohydrates)
  Manihot utilissima Pohl
Manilkara littoralis (Kurz) Dubard (timber trees)
Manilkara zapota (L.) P. van Royen (edible fruits and nuts)
  Achras zapota L.
Maranta arundinacea L. (plants mainly producing carbohydrates)
Marsilia crenata Presl (lower plants)
Marsilia minuta L. (lower plants)
Medicago sativa L. (forages)
Medinilla crispata (L.) Blume (medicinal and poisonous plants)
Melastoma malabathricum L. (medicinal and poisonous plants)
Melastoma polyanthum Blume (medicinal and poisonous plants)
  Melastoma malabathricum L. f. *polyanthum* L.
Melastoma sanguineum Sims (medicinal and poisonous plants)
  Melastoma decemfidum Roxburgh
Melocanna baccifera (Roxb.) Kurz (bamboos)
  Melocanna bambusoides Trin.
Melochia corchorifolia L. (medicinal and poisonous plants)
Melochia umbellata (Houtt.) O. Stapf (ornamental plants)
Memecylon caeruleum Jack (timber trees)
Mentha arvensis L. (medicinal and poisonous plants)
  Mentha javanica Blume
Merremia umbellata (L.) H. Hallier (medicinal and poisonous plants)
Metroxylon sagu Rottboel (plants mainly producing carbohydrates)
  Metroxylon rumphii (Willdenow) Martius
  Metroxylon squarrosum Beccari
Millettia atropurpurea (Wallich) Benth. (timber trees)
  Whitfordiodendron atropurpureum (Wallich) Merrill
  Whitfordiodendron pubescens (Craib) Burkill
Millettia sericea (Vent.) Wight & Arnott (medicinal and poisonous plants)
Mollugo pentaphylla L. (medicinal and poisonous plants)
Monstera deliciosa Liebm. (ornamental plants)
Morinda citrifolia L. (dye and tannin-producing plants)
Morinda umbellata L. (dye and tannin-producing plants)
Morus alba L. (forages)
Mucuna pruriens (L.) DC. cv. group Utilis (auxiliary plants in agriculture and forestry)
  Mucuna deeringiana (Bort.) Merrill
  Mucuna aterrima (Piper & Tracy) Merrill
  Mucuna cochinchinensis (Loureiro) A. Chevalier
  Mucuna utilis Wallich ex Wight
  Mucuna pruriens (L.) DC. var. *utilis* (Wallich ex Wight) Baker ex Burck
Mussaenda frondosa L. (medicinal and poisonous plants)
  Mussaenda glabra Vahl
Mussaenda villosa Wallich (medicinal and poisonous plants)
Myrica esculenta Buch.-Ham. (dye and tannin-producing plants)
  Myrica sapida Wallich

Myrica farquhariana Wallich
Myristica fragrans Houtt. (spices)
Nauclea orientalis (L.) L. (timber trees)
Sarcocephalus cordatus Miquel
Sarcocephalus undulatus Miquel
Naucoria spp. (lower plants)
Nelumbo nucifera Gaertner (ornamental plants)
Nelumbium nelumbo (L.) Druce
Nephrolepis biserrata (Swartz) Schott. (lower plants)
Nephrolepis acuta Presl
Nephrolepis hirsutula (Forster) Presl (lower plants)
Nostoc commune Vaucher (lower plants)
Nymphaea lotus L. (ornamental plants)
Nymphoides spp. (ornamental plants)
Limnanthemum spp.
Nypa fruticans Wurmb (plants mainly producing carbohydrates)
Ochrosia oppositifolia (Lamk) K. Schum. (timber trees)
Ocimum basilicum L. (spices)
Ocimum tenuiflorum L. (medicinal and poisonous plants)
Ocimum sanctum L.
Octomeles sumatrana Miquel (timber trees)
Olax imbricata Roxburgh (edible fruits and nuts)
Oncosperma horridum Scheffer (timber trees)
Oncosperma tigillarium (Jack) Ridley (timber trees)
Oncosperma filamentosum Blume
Operculina turpethum (L.) S. Manso (medicinal and poisonous plants)
Ophioglossum reticulatum L. (lower plants)
Orania sylvicola (Griffith) H.E. Moore (timber trees)
Orania macrocladus Martius
Oreocnide integrifolia Miquel (fibre plants)
Villebrunea integrifolia Gaudich.
Villebrunea sylvatica Blume
Oreocnide rubescens Miquel (fibre plants)
Villebrunea rubescens Blume
Villebrunea semierecta Blume sensu Heyne
Ormocarpum orientale (Sprengel) Merrill (auxiliary plants in agriculture and forestry)
Ormocarpum sennoides auct. non DC.
Oroxylum indicum (L.) Kurz (medicinal and poisonous plants)
Ottelia alismoides (L.) Pers. (auxiliary plants in agriculture and forestry)
Oudemansiella canarii (Junghuhn) von Hohnel (lower plants)
Oxalis barrelieri L. (spices)
Oxalis sepium A. St. Hilaire var. *picta* Progel
Oxalis corniculata L. (medicinal and poisonous plants)
Oxalis repens Thunberg
Oxalis corymbosa DC. (spices)
Oxalis latifolia Kunth (spices)
Oxalis tetraphylla Cav. (ornamental plants)
Pachyrhizus erosus (L.) Urban (plants mainly producing carbohydrates)

Paederia foetida L. (medicinal and poisonous plants)
Pandanus amaryllifolius Roxburgh (spices)
  Pandanus latifolius Hassk.
  Pandanus odorus Ridley
Pandanus furcatus Roxburgh (fibre plants)
  Pandanus houlletii Carr.
Pandanus polycephalus Lamk (fibre plants)
Pandanus tectorius Parkinson ex Z. (fibre plants)
  Pandanus bagea Miquel
  Pandanus robinsonii Merrill
Pangium edule Reinw. (medicinal and poisonous plants)
Parkia timoriana (DC.) Merrill (medicinal and poisonous plants)
  Parkia javanica (Lamk) Merrill
  Parkia roxburghii G. Don
  Parkia biglobosa auct. non Benth.
Passiflora foetida L. (auxiliary plants in agriculture and forestry)
Passiflora quadrangularis L. (edible fruits and nuts)
Pemphis acidula J.R. & G. Forster (timber trees)
Pentaspadon motleyi Hook.f. ex King (plants producing exudates)
  Pentaspadon officinalis Holmes
Peperomia pellucida (L.) Kunth (medicinal and poisonous plants)
Pereskia aculeata Miller (ornamental plants)
Pereskia bleo (Kunth) DC. (ornamental plants)
Perilla frutescens (L.) Britton (vegetable oils and fats)
  Perilla ocimoides L.
Perilla frutescens (L.) Britton var. *crispa* (Thunberg) Hand.-Mazz. (spices)
  Perilla nankinensis J. Decaisne
Persea americana Miller (edible fruits and nuts)
  Persea gratissima Gaertn.f.
Persicaria chinensis (L.) H. Gross (medicinal and poisonous plants)
  Polygonum chinense L.
Petroselinum crispum (Miller) A.W. Hill (spices)
  Petroselinum sativum Hoffm.
  Petroselinum vulgare Hill
  Petroselinum hortense Hoffm.
Phaeoclavulina zippelii (Leveille) van Overeem (lower plants)
  Clavaria zippelii Leveille
Phaseolus coccineus L. (pulses)
  Phaseolus multiflorus Lamk
Phaseolus lunatus L. (pulses)
Phaseolus vulgaris L. (pulses)
Phoenix dactylifera L. (edible fruits and nuts)
Phoenix paludosa Roxburgh (fibre plants)
Phragmites australis (Cav.) Steudel (fibre plants)
  Phragmites vulgaris (Lamk) Crépin
Phragmites karka (Retzius) Trinius ex Steudel (fibre plants)
  Phragmites communis Trinius (misappplied to *Phragmites karka* (Retzius) Trinius ex Steudel)
Phyllanthus acidus (L.) Skeels (edible fruits and nuts)

Cicca acida Merrill
Phyllanthus emblica L. (dye and tannin-producing plants)
Emblica officinalis Gaertner
Phyllostachys aurea Carr. ex A. & C. Rivière (bamboos)
Phymatodes longissima (Blume) J. Sm. (lower plants)
Pleopeltis longissima Moore
Phymatodes nigrescens (Blume) J. Sm. (lower plants)
Pleopeltis nigrescens Carr.
Physalis angulata L. (medicinal and poisonous plants)
Physalis minima L. (medicinal and poisonous plants)
Physalis peruviana L. (edible fruits and nuts)
Phytelephas macrocarpa Ruiz & Pavon (ornamental plants)
Pimeleodendron amboinicum Hassk. (plants producing exudates)
Pinanga basilanensis Beccari (ornamental plants)
Pinanga batanensis Beccari (ornamental plants)
Pinanga copelandii Beccari (ornamental plants)
Pinanga curranii Beccari (ornamental plants)
Pinanga elmeri Beccari (ornamental plants)
Pinanga geonomiformis Beccari (ornamental plants)
Pinanga heterophylla Beccari (ornamental plants)
Pinanga isabelensis Beccari (ornamental plants)
Pinanga maculata Porte ex Lemaire (ornamental plants)
Pinanga barnesii Beccari
Pinanga modesta Beccari (ornamental plants)
Pinanga negrosensis Beccari (ornamental plants)
Pinanga philippinensis Beccari (ornamental plants)
Pinanga punicea Merrill (timber trees)
Pinanga rigida Beccari (ornamental plants)
Pinanga samarana Beccari (ornamental plants)
Pinanga sclerophylla Beccari (ornamental plants)
Pinanga sibuyanensis Beccari (ornamental plants)
Pinanga speciosa Beccari (ornamental plants)
Pinanga urdanetana Beccari (ornamental plants)
Pinanga urosperma Beccari (ornamental plants)
Pinanga woodiana Beccari (ornamental plants)
Piper longum L. (spices)
Piper sarmentosum Roxburgh
Piper stylosum Miquel (medicinal and poisonous plants)
Pipturus argenteus (Forster) Wedd. (fibre plants)
Pisonia grandis R. Br. (ornamental plants)
Pisonia sylvestris Teijsm. & Binnend.
Pisonia alba Span.
Pistia stratiotes L. (forages)
Pisum sativum L. (pulses)
Pisum arvense L.
Plagiostachys uviformis (L.) Loesen. (medicinal and poisonous plants)
Alpinia uviformis Horan.
Languas uviformis Burkill
Planchonia grandis Ridley (timber trees)

Planchonia valida (Blume) Blume (timber trees)
Planchonia elliptica Miers
Plantago major L. (medicinal and poisonous plants)
Plectocomiopsis geminiflora (Griffith) Beccari (rattans)
Plectocomiopsis borneensis Beccari
Plectranthus rotundifolius (Poiret) Sprengel (plants mainly producing carbohydrates)
Coleus tuberosus (Blume) Benth.
Solenostemon rotundifolius (Poiret) J.K. Morton
Pleomele elliptica (Thunb.) N.E. Brown (ornamental plants)
Pleurotus anas van Overeem (lower plants)
Pleurotus ostreatus Fries (lower plants)
Pleurotus subocreatus Cooke (lower plants)
Ploiarium alternifolium (Vahl) Melchior (timber trees)
Archytaea vahlii Choisy
Pluchea indica (L.) Less. (medicinal and poisonous plants)
Plumeria rubra L. (ornamental plants)
Plumeria acuminata Aiton
Plumeria acutifolia Poiret
Plumiera acuminata Aiton
Polianthes tuberosa L. (ornamental plants)
Polycavernosa fastigiata Chang & Xia (lower plants)
Gracilaria lichenoides Harvey
Polygonum minus Hudson (auct., non Hudson) (medicinal and poisonous plants)
Polyporus arcularius (Batsch) Fries (lower plants)
Polyporus cocos (Fries) Weber (lower plants)
Polyporus grammocephalus Berkeley (lower plants)
Polyporus udus Junghuhn (lower plants)
Polyscias fruticosa (L.) Harms (ornamental plants)
Nothopanax fruticosum (L.) Miquel
Polyscias scutellaria (Burm.f.) Fosb. (ornamental plants)
Nothopanax scutellarium (Burm.f.) Merrill
Pometia pinnata J.R. & G. Forster (timber trees)
Pometia alnifolia Radlk.
Pometia tomentosa Teijsm. & Binnend.
Pongamia pinnata (L.) Pierre (auxiliary plants in agriculture and forestry)
Porana volubilis Burm. f. (ornamental plants)
Potentilla indica (H.C. Andrews) Wolf (edible fruits and nuts)
Fragaria indica H.C. Andrews
Pothomorphe peltata (L.) Miquel (medicinal and poisonous plants)
Heckeria peltata (L.) Kunth
Pothomorphe subpeltata (Willd.) Miquel (medicinal and poisonous plants)
Heckeria umbellata (L.) Kunth var. *subpeltata* (Willd.) Backer
Piper umbellatum L. var. *subpeltatum* (Willd.) C. DC.
Pothomorphe umbellata (L.) Miquel (medicinal and poisonous plants)
Piper umbellatum L.
Pouteria campechiana (Kunth) Baehni (edible fruits and nuts)
Lucuma nervosa A. DC.

Pouzolzia zeylanica (L.) Benn. (medicinal and poisonous plants)
Premna cordifolia Roxburgh (ornamental plants)
Premna divaricata Wallich (timber trees)
Premna odorata Blanco (timber trees)
  Premna tomentosa Willd.
Premna serratifolia L. (timber trees)
  Premna integrifolia L.
  Premna foetida Reinw. ex Blume
Prosopis spicigera L. (auxiliary plants in agriculture and forestry)
Protium javanicum Burm.f. (timber trees)
Protomarasmius helvelloides (Hennings & Nyman) van Overeem (lower plants)
Prunus mume Siebold & Zuccarini (edible fruits and nuts)
Pseudodeconica semiorbicularis (Bulliard) van Overeem (lower plants)
Psidium guajava L. (edible fruits and nuts)
Pteleocarpa lamponga (Miquel) Bakh. (timber trees)
Pteridium aquilinum Kuhn (lower plants)
Pteris ensiformis Burm. (lower plants)
Pterocarpus indicus Willd. (timber trees)
Pterospermum diversifolium Blume (timber trees)
  Pterospermum acerifolium Willd. sensu Heyne
Pterygota alata (Roxburgh) R. Br. (ornamental plants)
Ptychoraphis elmeri Beccari (ornamental plants)
Quisqualis indica L. (medicinal and poisonous plants)
Rhizophora mucronata Poiret (dye and tannin-producing plants)
Rhodopaxillus amethysteus (Berkeley & Broome) van Overeem (lower plants)
Ricinus communis L. (vegetable oils and fats)
Rosa chinensis Jacq. (ornamental plants)
  Rosa indica L. (probably *Rosa chinensis* Jacq.)
Rosa damascena Miller (ornamental plants)
Rosa luciae Franch. & Rochebr. ex Crepin (ornamental plants)
Rosa moschata J. Herm. (ornamental plants)
Rosa multiflora Thunberg ex Murray (ornamental plants)
Rosa transmorrisonensis Hayata (ornamental plants)
Roystonea oleracea (N.J. Jacquin) O.F. Cook (ornamental plants)
Roystonea regia (Kunth) O.F. Cook (ornamental plants)
Rubia cordifolia L. (dye and tannin-producing plants)
Rubus rosifolius J.E. Smith (medicinal and poisonous plants)
Russula cyanoxantha (Schaeffer) Fries (lower plants)
Russula foetens (Persoon) Fries (lower plants)
Russula lepida Fries (lower plants)
Russula virescens (Schaeffer) Fries (lower plants)
Saccharum officinarum L. (plants mainly producing carbohydrates)
Saccharum spontaneum L. (forages)
Sagittaria sagittifolia L. (plants mainly producing carbohydrates)
  Sagittaria sagittaefolia L.
Salacca zalacca (J. Gaertner) Voss (edible fruits and nuts)
  Salacca blumeana Martius var. *rimbo* Beccari
  Salacca edulis Reinwardt
Samanea saman (Jacq.) Merrill (auxiliary plants in agriculture and forestry)

Enterolobium saman (Jacq.) Prain
Sapindus saponaria L. (medicinal and poisonous plants)
Sapindus mukorossi Gaertner
Sarcodia montagneana (Harvey & Hook.) J. Agardh (lower plants)
Mastocarpus klenzeanus Kuetzing
Sarcolobus globosus Wallich (medicinal and poisonous plants)
Sargassum aquifolium (Turner) C. Agardh (lower plants)
Sargassum granuliferum C. Agardh (lower plants)
Sargassum myriocystum J. Agardh (lower plants)
Sargassum polycystum C. Agardh (lower plants)
Schima wallichii (DC.) Korth. ssp. *noronhae* (Reinw. ex Blume) Bloembergen var. *noronhae* (timber trees)
Schima noronhae Reinw. ex Blume
Schizophyllum commune Fries (lower plants)
Schizophyllum alneum (L.) Schroeter
Schizostachyum brachycladum Kurz (bamboos)
Schizostachyum lima (Blanco) Merrill (bamboos)
Schizostachyum lumampao (Blanco) Merrill (bamboos)
Bambus lumampao Blanco
Schizostachyum zollingeri Steudel (bamboos)
Schleichera oleosa (Loureiro) Oken (vegetable oils and fats)
Scleroderma aurantium Persoon (lower plants)
Scleroderma aureum Massee (lower plants)
Scorodocarpus borneensis (Baillon) Beccari (timber trees)
Selaginella fimbriata Spring. (lower plants)
Selaginella plana Hieron. (lower plants)
Selaginella caudata (Desv.) Spring.
Selaginella willdenowii Baker (lower plants)
Semecarpus anacardium L.f. (edible fruits and nuts)
Semecarpus cassuvium Roxburgh (edible fruits and nuts)
Sesbania grandiflora (L.) Poiret (forages)
Sesbania javanica Miquel (ornamental plants)
Sesbania roxburghii Merrill
Sesbania sericea (Willd.) Link (auxiliary plants in agriculture and forestry)
Sesbania cannabina Pers.
Sesbania sesban (L.) Merrill (forages)
Sesbania aegyptiaca Poiret
Setaria barbata (Lamk) Kunth (forages)
Panicum barbatum Lamk
Setaria clivalis (Ridley) Veldk. (forages)
Panicum chamaeraphoides Hackel
Setaria palmifolia (Koenig) Stapf (forages)
Panicum palmifolium Koenig
Sinapis alba L. (spices)
Brassica alba Rabenh.
Smilax australis R. Br. (plants mainly producing carbohydrates)
Smilax bracteata Presl (medicinal and poisonous plants)
Smithia sensitiva Aiton (medicinal and poisonous plants)
Solanum aculeatissimum Jacq. (medicinal and poisonous plants)

Solanum erianthum D. Don (medicinal and poisonous plants)
Solanum verbascifolium L.
Solanum mammosum L. (medicinal and poisonous plants)
Solanum tuberosum L. (plants mainly producing carbohydrates)
Sonneratia alba J. Smith (timber trees)
Sonneratia griffithii Kurz (timber trees)
Sphaerostephanos heterocarpon (Blume) Holtt. (lower plants)
Nephrodium heterocarpum Moore
Spondias cytherea Sonnerat (edible fruits and nuts)
Spondias dulcis Soland. ex Forster f.
Spondias mombin L. (edible fruits and nuts)
Spondias lutea L.
Spondias pinnata (L.f.) Kurz (spices)
Stachytarpheta jamaicensis (L.) Vahl (medicinal and poisonous plants)
Staurogyne elongata (Blume) O. Kuntze (medicinal and poisonous plants)
Stenochlaena palustris Bedd. (lower plants)
Strombosia javanica Blume (timber trees)
Strombosia philippinensis (Baillon) Rolfe (timber trees)
Symplocos odoratissima (Blume) Choisy ex Zollinger (dye and tannin-producing plants)
Synedrella nodiflora (L.) Gaertner (medicinal and poisonous plants)
Syzygium lineatum (DC.) Merrill & Perry (timber trees)
Eugenia lineata (DC.) Duthie
Eugenia longiflora Fischer
Syzygium malaccense (L.) Merrill & Perry (edible fruits and nuts)
Eugenia malaccensis L.
Syzygium polycephalum (Miquel) Merrill & Perry (edible fruits and nuts)
Eugenia polycephala Miquel
Syzygium pycnanthum Merrill & Perry (edible fruits and nuts)
Eugenia densiflora (Blume) Duthie
Talinum paniculatum (Jacq.) Gaertner (ornamental plants)
Talinum patens (L.) Willd.
Tamarindus indica L. (edible fruits and nuts)
Tectaria crenata Cavanilles (lower plants)
Aspidium repandum Willd.
Telosma cordata (Burm.f.) Merrill (ornamental plants)
Tetrastigma harmandii Planchon (edible fruits and nuts)
Themeda gigantea (Cav.) Hackel (forages)
Themeda villosa Durand & Jackson (misapplied to *Themeda gigantea* (Cav.) Hackel)
Thespesia populnea Sol. ex Correa (auxiliary plants in agriculture and forestry)
Thyrsostachys oliveri Gamble (bamboos)
Thyrsostachys siamensis Gamble (bamboos)
Tiliacora triandra (Colebr.) Diels (medicinal and poisonous plants)
Trachyspermum roxburghianum Craib (essential-oil plants)
Carum roxburghianum Benth.
Trachyspermum involucratum Wolff
Trema orientalis (L.) Blume (auxiliary plants in agriculture and forestry)
Trevesia burckii Boerl. (medicinal and poisonous plants)

Trevesia cheirantha (Clarke) O. Kuntze
Trevesia sundaica Miquel (ornamental plants)
Triumfetta rhomboidea Jacq. (fibre plants)
Triumfetta bartramia L.
Tropaeolum majus L. (ornamental plants)
Turbinaria conoides (J. Agardh) Kuetzing (lower plants)
Turbinaria ornata (Turner) J. Agardh (lower plants)
Typha angustifolia L. (fibre plants)
Typha domingensis Pers. var. *javanica* Geze
Ulva latissima L. (lower plants)
Umbilicaria esculenta (Miyoshi) Minks (lower plants)
Gyrophora esculenta Miyoshi
Uvaria rufa Blume (medicinal and poisonous plants)
Uvaria ridleyi King
Vaccinium varingiaefolium (Blume) Miquel (auxiliary plants in agriculture and forestry)
Veitchia merrillii (Beccari) H.E. Moore (ornamental plants)
Adonidia merrillii Beccari
Velolentinus giganteus (Berkeley) van Overeem (lower plants)
Vernonia cinerea (L.) Less. (medicinal and poisonous plants)
Vernonia patula (Dryander) Merrill (medicinal and poisonous plants)
Vernonia chinensis Less.
Vicia faba L. (pulses)
Victoria amazonica (Poeppig) Sowerby (ornamental plants)
Victoria regia Lindley
Vigna aconitifolia (Jacq.) Maréchal (pulses)
Phaseolus aconitifolius Jacq.
Vigna angularis (Willd.) Ohwi & Ohashi (pulses)
Phaseolus angularis (Willd.) W.F. Wright
Vigna dalzelliana (O. Kuntze) Verdc. (pulses)
Vigna marina (Burman) Merrill (auxiliary plants in agriculture and forestry)
Vigna mungo (L.) Hepper (pulses)
Phaseolus mungo L.
Vigna radiata (L.) Wilczek (pulses)
Phaseolus radiatus L.
Phaseolus aureus Roxburgh
Vigna subterranea (L.) Verdc. (pulses)
Voandzeia subterranea (L.) Thouars
Vigna umbellata (Thunberg) Ohwi & Ohashi (pulses)
Phaseolus calcaratus Roxburgh
Vigna unguiculata (L.) Walp. ssp. *cylindrica* (L.) van Eseltine (pulses)
Dolichos biflorus L.
Vigna catjang (Burm. f.) Walp.
Vigna unguiculata (L.) Walp. ssp. *unguiculata* (pulses)
Dolichos unguiculatus L.
Vigna sinensis (L.) Hassk.
Vitex pinnata L. (timber trees)
Vitex pubescens Vahl
Vitis flexuosa Thunberg (edible fruits and nuts)

Volvaria volvacea (Bulliard) Fries var. *edulis* van Overeem (lower plants)
Volvariella volvacea (Bulliard ex Fries) Sing (lower plants)
Wahlenbergia marginata (Thunberg ex Murray) A. DC. (medicinal and poisonous plants)
Wallichia disticha T. Anderson (ornamental plants)
Wollastonia biflora (L.) DC. (medicinal and poisonous plants)
  Wedelia biflora DC.
Wollastonia moluccana (Blume) DC. (medicinal and poisonous plants)
  Wedelia moluccana Boerl.
Woroninella psophocarpi Raciborski (lower plants)
Wrightia tinctoria R. Br. (dye and tannin-producing plants)
Xanthosoma sagittifolium (L.) Schott (plants mainly producing carbohydrates)
Xanthosoma violaceum Schott (plants mainly producing carbohydrates)
Ximenia americana L. (edible fruits and nuts)
Yushania niitakayamensis (Hayata) Keng f. (bamboos)
  Arundinaria niitakayamensis Hayata
Zantedeschia aethiopica (L.) Sprengel (ornamental plants)
Zantedeschia albomaculata (Hook.) Baillon (ornamental plants)
  Zantedeschia albomarginata Baillon (probably error for *Zantedeschia albomaculata* (Hook.) Baillon)
Zea mays L. (cereals)
Zehneria indica (Loureiro) Keraudren (medicinal and poisonous plants)
  Melothria indica Loureiro
Zingiber amaricans Blume (spices)
Zingiber aromaticum Valeton (spices)
Zingiber odoriferum Blume (edible fruits and nuts)
Zingiber officinale Roscoe (spices)
Zingiber zerumbet (L.) J.E. Smith (medicinal and poisonous plants)
Ziziphus mauritiana Lamk (edible fruits and nuts)
  Ziziphus jujuba (L.) Gaertner, non Miller, often cited as Lamk

Literature

Astley, D., Innes, N.L. & van der Meer, Q.P., 1982. Genetic resources of the Allium species. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 38 pp.

AVRDC, 1977. Proceedings of the workshop on pre- and post-harvest vegetable technology in Asia, February 7–12, 1977. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. 156 pp.

AVRDC, 1988a. Vegetable research in South-East Asia. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. 242 pp.

AVRDC, 1988b. Gardening nutritious vegetables. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. 136 pp.

AVRDC, 1990. Vegetable production training manual. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. 447 pp.

AVRDC, 1991. Vegetables research and development in the 1990s: a strategic plan. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Tainan, Taiwan. 61 pp.

Backer, C.A., 1928–1934. Onkruidflora der Javasche suikerrietgronden. Handboek ten dienste van de suikerriet cultuur en de rietsuiker fabricage op Java [Weed flora of Javanese sugar-cane fields. Handbook for the cultivation of sugar-cane and manufacturing of cane-sugar in Java]. Vereniging het Proefstation voor de Java-Suikerindustrie. 4 volumes. 907 pp.

Backer, C.A. & Bakhuizen van den Brink Jr, R.C., 1963–1968. Flora of Java. 3 volumes. Wolters-Noordhoff, Groningen, the Netherlands. Vol.1 (1963) 647 pp., Vol.2 (1965) 641 pp., Vol. 3 (1968) 761 pp.

Backer, C.A. & van Slooten, D.F., 1924. Geïllustreerd handboek der Javaansche theeonkruiden en hunne betekenis voor de cultuur [Illustrated handbook of weeds of Javanese tea plantations and their significance for tea-growing]. Ruygrok, Batavia, Dutch East Indies. 308 pp.

Bailey, L.H., 1960. The standard cyclopedia of horticulture. MacMillan, New York, United States. 910 pp.

Bailey, L.H., 1975. Manual of cultivated plants. 15th printing of 1951 edition (1st edition, 1924). MacMillan, New York, United States. 1116 pp.

Barrau, J., 1962. Les plantes alimentaires de l'Océanie, origines, distribution et usages [The edible plants of Oceania, origins, distribution and uses]. University of Aix-Marseille, Faculty of Sciences, Thesis No 71. 275 pp.

Bassett, M.J. (Editor), 1986. Breeding vegetable crops. Avi Publishing Company, Westport, Connecticut, United States. 584 pp.

Bates, D.M., Robinson, R.W. & Jeffrey, C. (Editors), 1990. Biology and utilization of the Cucurbitaceae. Comstock, Cornell University Press, Syracuse, New York, United States. 485 pp.

Bettencourt, E. & Konopka, J., 1990. Directory of germplasm collections. 4.

Vegetables. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 250 pp.

Bianchini, F., Corbetta, F. & Pistoia, M., 1976. The complete book of fruits and vegetables. Crown Publishers, New York, United States. 303 pp.

Bittenbender, H.C., 1983. Handbook of tropical vegetables. Michigan State University, East Lansing, United States. 118 pp.

Boonkird, S., Saakorn, J. & Sadakorn, T., 1982. Chue phanmai nai Muangthai [Names of plants in Thailand]. P. Chirakarnphim, Bangkok, Thailand. 657 pp.

Bose, T.K. & Som, M.G. (Editors), 1986. Vegetable crops in India. Naya Prokash Press, Calcutta, India. 775 pp.

BPS, 1983. Statistical yearbook of Indonesia 1982. Biro Pusat Statistik [Central Bureau of Statistics], Jakarta, Indonesia.

Brewster, J.L. & Rabinowitch, H.D. (Editors), 1990. Onions and allied crops. Vol. 3. Biochemistry, food science, and minor crops. 265 pp. CRC Press, Boca Raton, Florida, United States. (Vols. 1 and 2: see Rabinowitch, H.D. & Brewster, J.L., 1990).

Brown, W.H., 1941–1943. Useful plants of the Philippines. 3 volumes. Department of Agriculture and Natural Resources. Technical Bulletin 10. Bureau of Printing, Manila, the Philippines. 1610 pp. (reprint, 1951–1957).

Brücher, H., 1977. Tropische Nutzpflanzen. Ursprung, Evolution und Domestikation [Tropical useful plants. Origin, evolution and domestication]. Springer-Verlag, Berlin, Germany. 529 pp.

Buijsen, J.R.M., 1990. Taxonomic survey of Allium species cultivated in South-East Asia. Mimeographed report. Rijksherbarium, Leiden, the Netherlands. 47 pp.

Buishand, T., Houwing, H.P. & Jansen, K., 1986. Groenten uit alle windstreken [Vegetables from all corners of the world]. Spectrum, Utrecht, the Netherlands. 180 pp.

Burkill, I.H., 1935. A dictionary of the economic products of the Malay Peninsula. 2 volumes. Crown Agents for the Colonies, London, United Kingdom. 2402 pp. (slightly revised reprint, 1966. 2 volumes. Ministry of Agriculture and Cooperatives, Kuala Lumpur, Malaysia. 2444 pp.).

Busson, F., 1965. Plantes alimentaires de l'Ouest africain [Food plants of West Africa]. Ministère de la Coopération, Paris, France. 568 pp.

Buurma, J.S. & Basuki, R.S., 1989. From statistical data to research regions. Acta Horticulturae 270: 147–152.

Cannell, M.G.R., 1989. Food crop potential of tropical trees. Experimental Agriculture 25: 313–326.

Cobley, L.S. & Steele, W.M., 1976. An introduction to the botany of tropical crops. Longman, London, United Kingdom. 372 pp.

Corner, E.J.H., 1988. Wayside trees of Malaya. 3rd edition. 2 volumes. The Malayan Nature Society, Kuala Lumpur, Malaysia.

Corner, E.J.H. & Watanabe, K., 1969. Illustrated guide to tropical plants. Hirokawa Publishing Co., Tokyo, Japan. 1147 pp.

Crevost, Ch., Lemarié, Ch. & Petelot, A., 1917–1941. Catalogue des produits de l'Indochine [Catalogue of products from Indo-China]. 6 volumes. Gouvernement Général de l'Indochine. Imp. d'Extrême-Orient, Hanoi, Vietnam. 1944 pp.

Criel, D., 1989. Bijzondere groenten in Uw moestuin [Unusual vegetables in your vegetable garden]. Zomer & Keuning Boeken, Ede, the Netherlands. 251 pp.

Dalziel, J.M., 1937. The useful plants of west tropical Africa (Appendix to Hutchinson, J. & Dalziel, J.M.: Flora of west tropical Africa). Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 612 pp.

Department of Primary Industry, 1983. Leafy vegetables. Farming notes 30. Department of Primary Industry, Port Moresby, Papua New Guinea. 40 pp.

de Wilde-Duyfjes, B.E.E., 1976. A revision of the genus Allium L. (Liliaceae) in Africa. Mededelingen Landbouwhogeschool Wageningen 76–11. 239 pp.

Dharma, A.P., 1987. Indonesian medicinal plants. Balai Pustaka, Jakarta, Indonesia. 214 pp.

Dransfield, J. & Manokaran, N. (Editors), 1993. Plant resources of South-East Asia 6. Rattans. Pudoc/Prosea, Wageningen, the Netherlands. ca. 175 pp.

El-Zik, K.M. & Frisbie, R.E., 1985. Integrated crop management systems for pest control. In: Mandava, N.B. (Editor): CRC handbook of natural pesticides: methods. Vol. 1. Theory, practice and detection. CRC Press, Boca Raton, Florida, United States. pp. 21–122.

Engel, J., 1975. Underexploited tropical plants with promising economic value. National Academy of Sciences, Washington, D.C., United States. 189 pp.

Esquinas-Alcazar, J.T., 1981. Genetic resources of tomatoes and wild relatives. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 65 pp.

Esquinas-Alcazar, J.T. & Gulick, P.J., 1983. Genetic resources of Cucurbitaceae. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 101 pp.

Eveleens, K.G. & Vermeulen, H., 1976. Crop protection in Indonesian horticulture; some general considerations. Bulletin Penelitian Hortikultura [Horticultural Research Bulletin] 4(5): 3–18.

Everaarts, A.P., 1981. Weeds of vegetables in the highlands of Java. Horticultural Research Institute, Jakarta, Indonesia. 121 pp.

FAO, 1972. Food composition table for use in East Asia. FAO, Rome, Italy. 334 pp.

FAO, 1981–1990. FAO production yearbooks 1980–1989. Vol. 34–43. FAO, Rome, Italy.

FAO, 1981–1990. FAO trade yearbooks 1980–1989. Vol. 34–43. FAO, Rome, Italy.

FAO, 1984. Food and fruit-bearing forest species. 2. Examples from south-eastern Asia. FAO Forestry paper 44/2. Rome, Italy. 167 pp.

FAO, 1988. Vietnam. Agricultural and food production sector review. Mission report FAO/World Bank DD:DP/VIE/88/033. FAO, Rome, Italy. pp. 72–73.

FFTC, 1987. The breeding of horticultural crops. FFTC Book Series No 35. Food and Fertilizer Technology Center for the Asian and Pacific Region (FFTC), Taiwan. 273 pp.

FFTC, 1987. Improved vegetable production in Asia. FFTC Book Series No 36. Food and Fertilizer Technology Center for the Asian and Pacific Region (FFTC), Taiwan. 207 pp.

Flore du Cambodge, du Laos et du Vietnam [Flora of Cambodia, Laos and Vietnam] (various editors), 1960– . Vol. 1–24. Muséum National d'Histoire Naturelle, Laboratoire de Phanérogamie, Paris, France.

French, B.R., 1986. Food plants of Papua New Guinea, a compendium.

Australia Pacific Science Foundation. 407 pp.
Friedhelm, G., 1985. Subsistence agriculture improvement manual. Handbook No 10, Wau Ecology Institute, Wau, Papua New Guinea.
Fritz, D., Stolz, W., Venter, F., Weichmann, J. & Wonneberger, C., 1989. Gemüsebau [Vegetable growing]. 9th revised edition. Ulmer, Stuttgart, Germany. 379 pp.
George, R.A.T., 1985. Vegetable seed production. Longman, New York, United States. 318 pp.
Groosman, T. (Editor), 1988. Seed industry development. IVO, Development Research Institute, Tilburg, the Netherlands. Research report No 34. 91 pp.
Groot, S., van Balen, J. & de Hoop, S.J., 1988. The vegetable seed industry in South-East Asia. Case: the East-West Seed Company. In: Groosman, T. (Editor): Seed industry development. IVO, Development Research Institute, Tilburg, the Netherlands. Research report No 34. pp. 77–87.
Grubben, G.J.H., 1967. L'horticulture en Côte d'Ivoire [Horticulture in Ivory Coast]. Mission FAO. Ministère de l'Agriculture, Rép. de Côte d'Ivoire, Abidjan, Ivory Coast. 81 pp.
Grubben, G.J.H., 1976. The cultivation of amaranth as a tropical leaf vegetable. Communication 67. Royal Tropical Institute, Amsterdam, the Netherlands. 207 pp.
Grubben, G.J.H., 1977. Tropical vegetables and their genetic resources. Tindall, H.D. & Williams, J.T. (Editors). International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 197 pp.
Grubben, G.J.H., 1978. Vegetable seeds for the tropics. Bulletin 301. Department of Agricultural Research, Royal Tropical Institute, Amsterdam, the Netherlands. 40 pp.
Grubben, G.J.H. & van Sloten, D.H., 1981. Genetic resources of amaranths: a global plan of action. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 57 pp.
Hartmann, H.T. & Kester, D.E., 1983. Plant propagation: principles and practices. 4th edition. Prentice Hall Inc., Englewood Cliffs, New Jersey, United States. 727 pp.
Haryono Semangun, 1989. Penyakit-penyakit tanaman hortikultura di Indonesia [Diseases of horticultural crops in Indonesia]. Gadjah Mada University Press, Yogyakarta, Indonesia. 850 pp.
Hawkes, J.G., Lester, R.N. & Skelding, A.D. (Editors), 1979. The biology and taxonomy of the Solanaceae. Academic Press, Linnean Society of London, Linnean Society Symposium Series Number 7. 738 pp.
Hayward, H.E., 1967. The structure of economic plants. MacMillan, New York, United States. 674 pp.
Hegi, G., 1906–1931. Illustrierte Flora von Mitteleuropa [Illustrated flora of Central Europe]. Vols. 1–7. Lehmanns Verlag, München, Germany. (2nd and 3rd editions 1935– .)
Henderson, C.P. & Hancock, I.R., 1988. A guide to the useful plants of Solomon Islands. Ministry of Agriculture and Lands, Honiara, Solomon Islands. 481 pp.
Henderson, M.R., 1954. Malayan wild flowers: monocotyledons. The Malayan Nature Society, Kuala Lumpur, Malaysia. 357 pp.
Henderson, M.R., 1959. Malayan wild flowers: dicotyledons. The Malayan Nature Society, Kuala Lumpur, Malaysia. 478 pp.

Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. 525 pp.

Heyne, K., 1927. De nuttige planten van Nederlandsch Indië [The useful plants of the Dutch East Indies]. 2nd edition. 3 volumes. Departement van Landbouw, Nijverheid en Handel in Nederlandsch Indië. 1953 pp. (3rd edition, 1950. van Hoeve, 's-Gravenhage/Bandung, the Netherlands/Indonesia. 1660 pp.).

Hooker, J.D., 1879. Flora of British India. L. Reeve & Co., Kent, United Kingdom.

Hotta, M., Ogata, K., Nitta, A., Hosikawa, K., Yanagi, M. & Yamazaki, K. (Editors), 1989. Sekai yuhyou-shokubutu jiten [Useful plants of the world]. Heibonsha, Tokyo, Japan. 1499 pp.

Huke, R.E., 1982. Agroclimatic and dry-season maps of South, South-East and East Asia. IRRI, Los Baños, the Philippines. 15 pp. + 5 maps.

Hutchinson, J. & Dalziel, J.M., 1954. Flora of west tropical Africa. Crown Agents for Overseas Governments and Administrations, London, United Kingdom.

Huxley, A., Griffiths, M. & Levy, M. (Editors), 1992. The new Royal Horticultural Society dictionary of gardening. 4 volumes. MacMillan, London, United Kingdom.

IBPGR, 1981. Genetic resources of cruciferous crops. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 48 pp.

IBPGR, 1983. Genetic resources of Capsicum. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 49 pp.

IFA, 1992. World fertilizer use manual. International Fertilizer Industry Association (IFA), Paris, France. 632 pp.

Irvine, F.R., 1969. West African crops. Oxford University Press, United Kingdom. 272 pp.

Ishemat Soerianegara & Lemmens, R.H.M.J. (Editors), 1993. Plant resources of South-East Asia 5(1). Timber trees – Major commercial timbers. Pudoc/Prosea, Wageningen, the Netherlands. ca. 600 pp.

Jacquat, C., 1990. Plants from the markets of Thailand. Editions Duang Kamol, Bangkok, Thailand. 251 pp.

Jansen, P.C.M., Lemmens, R.H.M.J., Oyen, L.P.A., Siemonsma, J.S., Stavast, F.M. & van Valkenburg, J.L.C.H. (Editors), 1991. Plant resources of South-East Asia. Basic list of species and commodity grouping. Final version. Pudoc/Prosea, Wageningen, the Netherlands. 372 pp.

Jeffrey, C., 1980. A review of the Cucurbitaceae. Botanical Journal of the Linnean Society 81: 233–247.

Jones, D.T. & Kalsom bt. Osman, 1984. Tropical tree species as potential alternative vegetables. In: Mohammad Md. Ali & Lim Eng Siong (Editors): Vegetables and ornamentals in the tropics. Proceedings of a symposium, October 27–28, 1982, Serdang, Malaysia. Universiti Pertanian Malaysia, Serdang, Malaysia. pp. 101–118.

Jones, H.A. & Mann, L.K., 1963. Onions and their allies. Botany, cultivation and utilization. Leonard Hill, London, United Kingdom. 286 pp.

Kalshoven, L.G.E., 1981. Pests of crops in Indonesia. English revised edition (translation of 'De plagen van cultuurgewassen in Indonesië', 1950–1951). Ichtiar Baru/van Hoeve, Jakarta, Indonesia. 701 pp.

Knott, J.E. & Deanon Jr, J.R. (Editors), 1967. Vegetable production in South-East Asia. University of the Philippines Press, Los Baños, the Philippines. 366 pp.

Kroll, R., 1957. De groenteteelt in Belgisch-Congo [Vegetable growing in Belgian Congo]. Directie van Landbouw, Bossen en Veeteelt, Brussel, Belgium. 134 pp.

Krug, H., 1991. Gemüseproduktion [Vegetable production]. 2nd edition. Verlag Paul Parey, Berlin, Germany. 541 pp.

Kuebel, K.R. & Tucker, A.O., 1988. Vietnamese culinary herbs in the United States. Economic Botany 42(3): 413–419.

Kurz, W.S., 1877. Forest flora of British Burma. 2 volumes. Office of the Superintendent of Government Printing, Calcutta, India.

Laderman, C., 1982. Wild vegetable consumption on the east coast of Peninsular Malaysia. Malay. Nat. J. 35: 165–171.

Landauer, K. & Brazil, M. (Editors), 1990. Tropical home gardens. United Nations University Press, Tokyo, Japan. 257 pp.

Lang, R.M., 1989. Fijne en zeldzame groenten [Fine and rare vegetables]. Uitgeverij Terra, Zutphen, the Netherlands. 128 pp.

Langer, R.H.M. & Hill, G.D., 1982. Agricultural plants. Cambridge University Press, United Kingdom. 344 pp.

Larkcom, J., 1991. Oriental vegetables. The complete guide for garden and kitchen. John Murray, London, United Kingdom. 232 pp.

Laumans, Q., Kasijadi, F., Leksono, S., Nusantoro, B. & Santoso, P., 1985. The home gardens of East Java: results of an agro-economic survey. Malang Research Institute for Food Crops (MARIF/AARD), Malang, Indonesia. 29 pp.

Lecomte, M.H. & Gagnepain, F. (Editors), 1907–1950. Flore générale de l'Indo-Chine [General flora of Indo-China]. 7 volumes and supplements. Muséum National d'Histoire Naturelle, Paris, France.

Lee Ying Fah & Aban Gibot, 1986. Indigenous edible plants of Sabah. Forest Research Centre, Sepilok, Sabah, Malaysia. Publication No 25: 1–9.

Lemmens, R.H.M.J. & Wulijarni-Soetjipto, N. (Editors), 1991. Plant resources of South-East Asia 3. Dye and tannin-producing plants. Pudoc/Prosea, Wageningen, the Netherlands. 195 pp.

Li, Hui-Lin et al. (Editors), 1975–1978. Flora of Taiwan. 5 volumes. Epoch Publishing Company, Taipei, Taiwan.

Lolo, M., 1982. A survey of traditional vegetables in the Gazelle Peninsula, East New Britain. In: Proceedings of the Second Papua New Guinea Food Crops Conference, July 14–18, 1980, Goroka. Department of Primary Industry, Port Moresby, Papua New Guinea. pp. 148–159.

Lorenz, O.A. & Maynard, D.N., 1988. Knott's handbook for vegetable growers. John Wiley and Sons, New York, United States. 456 pp.

Lovelock, Y., 1972. The vegetable book. St. Martin's Press, New York, United States. 383 pp.

Mabberley, D.J., 1981. The plant book. A portable dictionary of the higher plants. Cambridge University Press, Cambridge, United Kingdom. 706 pp.

Macmillan, H.F., 1962. Tropical planting and gardening. 5th edition. MacMillan & Co., London, United Kingdom. 560 pp.

Mandava, N.B. (Editor), 1985. CRC handbook of natural pesticides: methods. Vol. 1. Theory, practice and detection. CRC Press, Boca Raton, Florida, United States.

Mansfeld, R., 1986. Verzeichnis landwirtschaftlicher und gärtnerischer Kulturpflanzen (ohne Zierpflanzen) [Register of agricultural and horticultural plants in cultivation (without ornamentals)]. Schultze-Motel, J. et al., editors 2nd edition, 4 volumes. Springer Verlag, Berlin, Germany. 1998 pp.

Mansor, P., 1988. Ulam-ulam tradisional Malaysia [Traditional vegetables in Malaysia]. Teknologi Sayur-sayuran [Vegetable Technology] 4: 1–5.

MARDI, 1985. Proceedings of the national vegetable workshop, August 12–13, 1985. Malaysian Agricultural Research and Development Institute (MARDI), Serdang, Malaysia. 187 pp.

Martin, F.W. & Ruberté, R.M., 1975. Edible leaves of the tropics. Antillian College Press, Mayaguez, Puerto Rico, United States. 235 pp.

Massal, F. & Barrau, J., 1956. Food plants of the South Sea Islands. SPC Technical Paper No 94. Noumea, New Caledonia. 51 pp.

Matthew, K.M., 1981–1983. The flora of the Tamilnadu Carnatic. 3 volumes. The Rapinat Herbarium, Tiruchirapalli, India.

Mehra, K.L. & Sastrapradja, S. (Editors), 1985. Proceedings of the international symposium on South-East Asian plant genetic resources, August 20–24, 1985, Jakarta, Indonesia. Indonesian Institute of Sciences (LIPI), Bogor, Indonesia. 211 pp.

Merrill, E.D., 1912. A flora of Manila. Bureau of Printing, Manila, the Philippines. 491 pp.

Merrill, E.D., 1923–1926. An enumeration of Philippine flowering plants. 4 Volumes. Bureau of Printing, Manila, the Philippines. 463, 530, 628, 515 pp. respectively.

Messiaen, C.-M., 1989. Le potager tropical [The tropical vegetable garden]. Presses Universitaires de France, Paris, France. 580 pp.

Messiaen, C.-M., Cohat, J., Leroux, J.P., Pichon, M. & Beyries, A., 1993. Les alliums alimentaires reproduits par voie végétative [Vegetatively reproduced Allium crops used for food]. Institut National de la Recherche Agronomique, Paris, France. 225 pp.

Mohammad Md. Ali & Lim Eng Siong (Editors), 1984. Proceedings of the symposium on vegetables and ornamentals in the tropics, October 27–28, 1982. Agricultural University of Malaysia, Serdang, Selangor, Malaysia. 310 pp.

Monsalud, M.R., Toñgacan, A.L., Lopez, F.R. & Lagrimas, M.Q., 1966. Edible wild plants in Philippine forests. Philippine Journal of Science 95(4): 431–561.

Mortensen, E. & Bullard, E.T., 1964. Handbook of tropical and subtropical horticulture. United States Agency for International Development, Communications Resources Division, Washington, D.C., United States. 260 pp.

Morton, J.F., 1981. Atlas of medicinal plants of Middle America (Bahamas to Yucatan). C.C. Thomas Publisher, Springfield, Illinois, United States. 1420 pp.

Naiola, B.P., 1986. Tanaman budidaya Indonesia, nama serta manfaatnya [Indonesian cultivated plants, their names and uses]. Yasaguna, Jakarta, Indonesia. 224 pp.

National Research Council, 1989. Lost crops of the Incas: little-known plants of the Andes with promise for worldwide cultivation. National Academy Press, Washington, D.C., United States. 415 pp.

Nicholson, B.E., Harrison, S.G., Masefield, G.B. & Wallis, M., 1969. The Oxford book of food plants. Oxford University Press, United Kingdom. 206 pp.

Nieuwhof, M., 1969. Cole crops. Leonard Hill, London, United Kingdom. 353 pp.

Niñez, V.K. (Editor), 1985. Household food production: comparative perspectives. International Potato Center (CIP). Food and Nutrition Bulletin 7(3): 1–67.

Nonnecke, I.L., 1989. Vegetable production. Van Nostrand Reinhold, New York, United States. 657 pp.

Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische groenten', 1931). Asher & Co., Amsterdam, the Netherlands. 1016 pp.

Oomen, H.A.P.C. & Grubben, G.J.H., 1978. Tropical leaf vegetables in human nutrition. Communication 69. Royal Tropical Institute, Amsterdam, the Netherlands. 140 pp.

Oomen, H.A.P.C., Poorwo Soedarmo, Djoeweriah Poorwo Soedarmo & Surachmat Kusumo, 1984. Si hijau yang cantik. Aneka sayuran daun hijau di Indonesia [Green is beautiful. Various leaf vegetables in Indonesia]. Gramedia, Jakarta, Indonesia. 188 pp.

Paijmans, K. (Editor), 1976. New Guinea vegetation. Elsevier Scientific Publishers, Amsterdam, the Netherlands. 213 pp.

Pancho, J.V. & Soerjani, M., 1978. Aquatic weeds of South-East Asia; a systematic account of common Southeast Asian aquatic weeds. National Publishing Cooperative, Quezon City, the Philippines. 130 pp.

Peekel, P.G., 1984. Flora of the Bismarck Archipelago for naturalists. English edition. Office of Forests, Division of Botany, Lae, Papua New Guinea. 638 pp.

Petelot, A., 1952–1954. Les plantes médicinales du Cambodge, du Laos et du Vietnam [Medicinal plants of Cambodia, Laos and Vietnam]. 4 volumes. Archives des Recherches Agronomiques et Pastorales au Vietnam No 14, 18, 22, 23. Vietnam.

Phongpha-ngan, S., 1972. Phuet kindai [Edible plants]. Witthayasart [Science] 26(4): 9–15.

Pierce, L.C., 1987. Vegetables: characteristics, production and marketing. John Wiley and Sons, New York, United States. 433 pp.

Platt, B.S., 1960. Tables of representative values of foods commonly used in tropical countries. Special report series No 302. Medical Research Council, London, United Kingdom. 46 pp.

Powell, J.M., 1976. Ethnobotany. In: Paijmans, K. (Editor): New Guinea vegetation. Elsevier Scientific Publishers, Amsterdam, the Netherlands. pp. 106–183.

Powell, J.M., 1982. Traditional vegetables in Papua New Guinea: retrospect and prospect. In: Proceedings of the Second Papua New Guinea Food Crops Conference, July 14–18, 1980, Goroka. Department of Primary Industry, Port Moresby, Papua New Guinea. pp. 64–77.

Purseglove, J.W., 1968–1972. Tropical crops. Longman, London, United Kingdom. Dicotyledons. 2 volumes (1968), 719 pp. Monocotyledons. 2 volumes (1972), 607 pp.

Quisumbing, E., 1951. Medicinal plants of the Philippines. Department of Agriculture and Natural Resources. Bureau of Printing, Manila, the Philippines.

Rabinowitch, H.D. & Brewster, J.L. (Editors), 1990. Onions and allied crops. Vol. 1. Botany, physiology, and genetics. 273 pp., Vol. 2. Agronomy, biotic interactions, pathology, and crop protection. 320 pp., CRC Press, Boca Raton, Florida, United States. (Vol. 3: see Brewster, J.L. & Rabinowitch, H.D., 1990).

Rehm, S. (Editor), 1989. Handbuch der Landwirtschaft und Ernährung in den Entwicklungsländern. Bd. 4. Spezieller Pflanzenbau in den Tropen und Subtropen [Handbook of agriculture and nutrition in underdeveloped countries. Vol. 4. Special plant cultivation in the tropics and subtropics]. 2nd edition. Eugen Ulmer, Stuttgart, Germany. 653 pp.

Reyes, L.P., 1938. Philippine woods. Department of Agriculture and Commerce Technical Bulletin 7. Bureau of Printing, Manila, the Philippines. 536 pp. + 88 plates.

Rice, R.P., Rice, L.W. & Tindall, H.D., 1990. Fruit and vegetable production in warm climates. International edition. MacMillan, London, United Kingdom. 486 pp.

Ridley, H.N., 1922–1925. The flora of the Malay Peninsula. 5 volumes. Government of the Straits Settlements and Federated Malay States. L. Reeve & Co., London, United Kingdom.

Roecklein, J.C. & Ping Sun Leung, 1987. A profile of economic plants. Transaction, New Brunswick, United States. 623 pp.

Roxburgh, W., 1832. Flora Indica. Carey edition. Reprint 1874. Thacker, Spink & Co., Calcutta, India. 763 pp. + lxiv pp.

Ryall, A.L. & Lipton, W.J., 1978. Handling, transportation and storage of fruits and vegetables. Avi Publishing Company, Westport, Connecticut, United States. 587 pp.

Samaka Service Center, 1962. The Samaka guide to homesite farming. Samaka Service Center, Manila, the Philippines. 168 pp.

Sastrapradja, S., Lubis, S.H.A., Djajasukma, E., Soetarno, H. & Lubis, I., 1981. Vegetables (translation of 'Sayur-sayuran', 1977). International Board for Plant Genetic Resources (IBPGR), Rome, Italy. 117 pp.

Schoneveld, J., 1992. Research on product quality. Report on a short mission on product quality and post-harvest technology. Lembang Horticultural Research Institute (LEHRI), Bandung, Indonesia. 45 pp.

Schubert, B. et al., 1982. Vegetables in East Kalimantan. Centre for Advanced Training in Agricultural Development, Technical University, Berlin, Germany. 284 pp.

Shanmugasundaram, S. (Editor), 1990. Vegetable research and development in South Asia. Proceedings of a workshop held at Islamabad, Pakistan, 24–29 September, 1990. AVRDC Publication 90–331, Shanhua, Taiwan. 194 pp.

Sherf, A.F. & Macnab, A.A., 1986. Vegetable diseases and their control. John Wiley & Sons, New York, United States. 728 pp.

Shinohara, S. (Editor), 1984–1989. Vegetable seed production technology of Japan. 2 volumes. Shinohara's Authorized Agricultural Consulting Engineer Office, Tokyo, Japan. Vol. 1 (1984) 432 pp., Vol. 2 (1989) 317 pp.

Siemonsma, J.S., 1982. La culture du gombo (Abelmoschus spp.), légume-fruit tropical (avec référence spéciale à la Côte d'Ivoire) [Cultivation of the tropical fruit-vegetable okra (Abelmoschus spp.), with special reference to Ivory Coast]. Thesis, Wageningen Agricultural University, the Netherlands. 297 pp.

Siemonsma, J.S. & Aarts-van den Bergh, M.H., 1989. Vegetables of South-East

Asia. In: Siemonsma, J.S. & Wulijarni-Soetjipto, N. (Editors): Plant resources of South-East Asia. Proceedings first Prosea international symposium, May 22–25, 1989, Jakarta, Indonesia. Pudoc, Wageningen, the Netherlands. pp. 142–153.

Siemonsma, J.S. & Wulijarni-Soetjipto, N. (Editors), 1989. Plant resources of South-East Asia. Proceedings first Prosea international symposium, May 22–25, 1989, Jakarta, Indonesia. Pudoc, Wageningen, the Netherlands. 337 pp.

Sillitoe, P., 1983. Roots of the earth: crops in the highlands of Papua New Guinea. Manchester University Press, United Kingdom. 285 pp.

Simmonds, N.W. (Editor), 1976. Evolution of crop plants. Longman, London, United Kingdom. 339 pp.

Singh, S.P., 1989. Production technology of vegetable crops. Agricultural Research Communication Center, India. 380 pp.

Smitinand, T. & Larsen, K. (Editors), 1970– . Flora of Thailand. Vol. 2, 3, 4 (1, 2), 5 (1, 2). The Forest Herbarium, Royal Forest Department, Bangkok, Thailand.

Soemarwoto, O., 1985. The Javanese home garden as an integrated agro-ecosystem. In: Niñez, V.K. (Editor): Household food production: comparative perspectives. International Potato Center (CIP). Food and Nutrition Bulletin 7(3): 44–47.

Soeparma Satiadiredja, 1950. De teelt en het gebruik van Indonesische groenten en toekruiden [The cultivation and use of Indonesian vegetables and condiments]. Wolters, Groningen, the Netherlands. 192 pp.

Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G., 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. 716 pp.

Splittstoesser, W.E., 1979. Vegetable growing handbook. Avi Publishing Company, Westport, Connecticut, United States. 298 pp.

Stevels, J.M.C., 1990. Légumes traditionnels du Cameroun, une étude agrobotanique [Traditional vegetables of Cameroun, an agro-botanic study]. Thesis. Wageningen Agricultural University Papers 90–1, Wageningen, the Netherlands. 262 pp.

Subhan, Sudjoko, Suwandi & Zainal Abidin (Editors), 1989. Bercocok tanam sayuran dataran rendah [Growing lowland vegetables]. Lembang Horticultural Research Institute (LEHRI), Bandung, Indonesia. 60 pp.

Sunaryono, H. & Rismunandar, 1984. Kunci bercocok tanam sayuran-sayuran penting di Indonesia [Guide for the cultivation of important vegetables in Indonesia]. Sinar Baru, Bandung, Indonesia. 155 pp.

Talekar, N.S. (Editor), 1992. Proceedings of the second international workshop on the management of diamondback moth and other crucifer pests (10–14 December, 1990). Asian Vegetable Research and Development Center (AVRDC), Tainan, Taiwan. AVRDC Publication 92–368. 603 pp.

Terra, G.J.A., 1966. Tropical vegetables. Communication 54. Royal Tropical Institute, Amsterdam, the Netherlands. 107 pp.

The Wealth of India, Raw materials (various editors), 1948–1976. 11 volumes. Publications and Information Directorate, Council of Scientific and Industrial Research, New Delhi, India. 4441 pp.

Thompson, H.C. & Kelly, W.C., 1978. Vegetable crops. Tata McGraw-Hill Publishing Company, New Delhi, India. 611 pp.

Tindall, H.D., 1965. Fruits and vegetables in West Africa. FAO Plant Production and Protection Series No 4. FAO, Rome, Italy. 257 pp.
Tindall, H.D., 1968. Commercial vegetable growing. Oxford University Press, United Kingdom. 300 pp.
Tindall, H.D., 1983. Vegetables in the tropics. MacMillan, London, United Kingdom. 533 pp.
Titulaer, H.H.H., 1991. Report of a short mission on fertilization and plant and soil analysis. Lembang Horticultural Research Institute (LEHRI), Bandung, Indonesia.
't Mannetje, L. & Jones, R.M. (Editors), 1992. Plant resources of South-East Asia 4. Forages. Pudoc/Prosea, Wageningen, the Netherlands. 300 pp.
Tsunoda, S., Hinata, K. & Gomez-Campo, C. (Editors), 1980. Brassica crops and wild allies: biology and breeding. Japan Scientific Societies Press, Tokyo, Japan. 354 pp.
Unus Suriawiria, 1987. Lalab dalam budaya dan kehidupan masyarakat Sunda [Lalab in the culture and life of Sundanese society]. Granesia, Bandung, Indonesia. 129 pp.
van Borssum Waalkes, J., 1966. Malesian Malvaceae revised. Blumea 14(1): 1–251.
van der Maesen, L.J.G. & Sadikin Somaatmadja (Editors), 1989. Plant resources of South-East Asia 1. Pulses. Pudoc/Prosea, Wageningen, the Netherlands. 105 pp.
van der Meijden, R., 1990. Heukels' Flora van Nederland [Heukels' Flora of the Netherlands]. 21st edition. Wolters-Noordhoff, Groningen, the Netherlands. 662 pp.
van der Zon, A.P.M. & Grubben, G.J.H., 1977. Les légumes-feuilles spontanés et cultivés du Sud-Dahomey [Wild and cultivated leaf vegetables of South Dahomey]. Communication 65. Department of Agricultural Research, Royal Tropical Institute, Amsterdam, the Netherlands. 111 pp.
van Epenhuijsen, C.W., 1974. Growing native vegetables in Nigeria. FAO, Rome, Italy. 113 pp.
van Lieshout, O., 1990. Consumption of fresh vegetables in Indonesia. A forecast for the year 2000. Internal communication LEHRI/ATA-395 No 6. Lembang Horticultural Research Institute (LEHRI), Bandung, Indonesia. 26 pp.
van Sloten, D.H., 1980. IBPGR activities on genetic resources of fruits and vegetables. Chronica Horticulturae 20(3): 49–52.
van Steenis, C.G.G.J. et al. (Editors), 1950– . Flora Malesiana. Series 1. Vol. 1, 4–10. Kluwer Academic Publishers, Dordrecht, the Netherlands.
Vavilov, N.I., 1951. The origin, variation, immunity and breeding of cultivated plants. Chronica Botanica 13(1–6), 1949/1950.
Verdcourt, B., 1979. A manual of New Guinea legumes. Botany Bulletin No 11. Office of Forests, Division of Botany, Lae, Papua New Guinea. 645 pp.
Verheij, E.W.M. & Coronel, R.E. (Editors), 1991. Plant resources of South-East Asia 2. Edible fruits and nuts. Pudoc/Prosea, Wageningen, the Netherlands. 446 pp.
Voon Boon Hoe, Patricia Sim & Chin Thian Hon, 1988. Sayur-sayuran dan buah-buahan hutan di Sarawak [Vegetables and fruits from the forest in Sarawak]. Department of Agriculture, Sarawak, Malaysia. 55 pp.

Vos, J.G.M. & Sumarni, N., 1990. Inventory of hot pepper production areas in the Indonesian lowland. Lembang Horticultural Research Institute (LEHRI), Bandung, Indonesia. Internal Communication 24. 35 pp.

Warburg, O., 1894. Plantae Hellwigianae. Beitrag zur Flora von Kaiser Wilhelms-Land [Plants collected by Hellwig. Contribution to the flora of Kaiser Wilhelms-Land]. Botanische Jahrbücher 18: 184–212.

Watts, L., 1980. Flower and vegetable plant breeding. Grower Books, London, United Kingdom. 182 pp.

Wealth of India (various editors), 1948–1976. A dictionary of Indian raw materials and industrial products: raw materials. 11 volumes. Publications and Information Directorate, Council of Scientific and Industrial Research, New Delhi, India. 4441 pp.

Westphal, E. et al., 1985. Cultures vivrières tropicales, avec référence spéciale au Cameroun [Tropical food crops, with special reference to Cameroun]. Pudoc, Wageningen, the Netherlands. 514 pp.

Westphal, E. & Jansen, P.C.M. (Editors), 1989. Plant resources of South-East Asia. A selection. Pudoc/Prosea, Wageningen, the Netherlands. 320 pp.

Whitaker, T.W. & Davis, G.N., 1962. Cucurbits: botany, cultivation and utilization. Leonard Hill, London, United Kingdom. 250 pp.

Williams, L.O., 1981. The useful plants of Central America. Ceiba 24(1–4): 1–381. Escuala Agricola Panamericana, Honduras.

Williams, J.T., Lamoureux, C.H. & Wulijarni-Soetjipto, N. (Editors), 1975. Proceedings of a symposium on South-East Asian plant genetic resources, March 20–22, 1975, Bogor, Indonesia. IBPGR/BIOTROP/LIPI, Bogor, Indonesia. 272 pp.

Winrock International, 1986. Research and development of vegetables in the tropics. Summary report of a conference, January 9–12, 1986, Morrilton, Arkansas, United States. 88 pp.

Winters, H.F. & Miskimen, G.W., 1967. Vegetable gardening in the Caribbean area. USDA Handbook 323, Washington, D.C., United States. 114 pp.

Wunderlin, R.P., 1978. Cucurbitaceae. In: Woodson, R.E. & Schery, R.W. (Editors): Flora of Panama. Annals of the Missouri Botanical Garden 65: 285–368.

Yamaguchi, M., 1983. World vegetables: principles, production and nutritive values. Avi Publishing Company, Westport, Connecticut, United States. 415 pp.

Yen, D.E. & Gutierrez, H.G., 1974. The ethnobotany of the Tasaday: the useful plants. Philippine Journal of Science 103(2): 97–139.

Zeven, A.C. & de Wet, J.M.J., 1982. Dictionary of cultivated plants and their regions of diversity: excluding most ornamentals, forest trees and lower plants. Pudoc, Wageningen, the Netherlands. 263 pp.

Acknowledgments

Our thanks are due to
- the Finnish International Development Agency (FINNIDA), for financial support;
- the Netherlands Ministry of Agriculture, Nature Management and Fisheries, Directorate Science and Technology (DWT), for financial support;
- the Netherlands Ministry of Foreign Affairs, Directorate-General for International Cooperation (DGIS), for financial support;
- the Chairman of the Indonesian Institute of Sciences (LIPI), Jakarta, Indonesia, for supporting the Prosea programme, and the Centre for Research and Development in Biology (CRDB), Bogor, Indonesia, for providing facilities for the Prosea Network Office in the Herbarium Bogoriense;
- the Executive Board of Wageningen Agricultural University, Wageningen, the Netherlands, for supporting the Prosea programme, and the Departments of Agronomy and Plant Taxonomy, for providing facilities for the Prosea Publication Office;
- the coordinating institutions of the Prosea programme in Indonesia, Malaysia, Papua New Guinea, the Philippines, Thailand and Vietnam, for providing facilities for the Prosea Country Offices;
- the Centre for Agricultural Publishing and Documentation (Pudoc), Wageningen, the Netherlands, for support and documentation facilities;
- the Prosea Country Officers in South-East Asia, for their search work on less-accessible literature, for their editorial support concerning vernacular names and statistics, and for logistical support for field trips and market visits of the editors;
- Ms Fadelah Abdul Aziz, Malaysian Agricultural Research and Development Institute (MARDI), Serdang, Malaysia, who made an initial contribution as Associate Editor before she had to withdraw for personal reasons;
- Ms Marita van den Bergh, who made important contributions to this volume, first as Prosea staff in the Network Office, Bogor, Indonesia, and later on a voluntary basis in the Netherlands during the editing process;
- Ms Carol Lynn Crow for her contributions to the editing of the English text;
- Dr J.E. Vidal and Mrs Dy Phon of the 'Laboratoire de Phanérogamie, Muséum National d'Histoire Naturelle', Paris, France, for assistance regarding the vernacular names for Laos and Cambodia;
- Mrs A. van der Lande, for assistance with typing;
- Ms M.J.C. Augustijn, for assistance in making the indexes;
- Mr L.E. Groen for assistance in finding sources of illustrations;
- all persons, institutions, publishers and authors mentioned in the list 'Sources of illustrations', for authorization to use these illustrations;
- institutions and companies, who made suggestions for form and contents of

this volume, in particular staff of the Malaysian Agricultural Research and Development Institute (MARDI), Serdang, Malaysia, and staff of the East-West Seed Company, Thailand;

- all persons who made suggestions for handling taxonomic problems, in particular B. Hansen (Botanical Museum, University of Copenhagen, Denmark), J. Dransfield (Royal Botanic Gardens, Kew, England), E.A. Widjaja (Herbarium Bogoriense, Bogor, Indonesia), and W.J.J.O de Wilde (Rijksherbarium, Leiden, the Netherlands)

Acronyms of organizations

- AVRDC: Asian Vegetable Research and Development Center (Shanhua, Tainan, Taiwan).
- CGN: Centrale Genenbank Nederland (Wageningen, the Netherlands).
- CRDB: Centre for Research and Development in Biology (Bogor, Indonesia).
- CRIH: Central Research Institute for Horticulture (Jakarta, Indonesia).
- FAO: Food and Agriculture Organization of the United Nations (Rome, Italy).
- FFTC: Food and Fertilizer Technology Center for the Asian and Pacific Region (Taipei, Taiwan).
- FRIM: Forest Research Institute of Malaysia (Kepong, Malaysia).
- IBPGR: International Board for Plant Genetic Resources (Rome, Italy).
- IEBR: Institute of Ecology and Biological Resources (Hanoi, Vietnam).
- IFA: International Fertilizer Industry Association (Paris, France).
- IPB: Institute of Plant Breeding, University of the Philippines (Los Baños, the Philippines).
- LEHRI: Lembang Horticultural Research Institute (Lembang, Indonesia).
- LIPI: Indonesian Institute of Sciences (Jakarta, Indonesia).
- MARDI: Malaysian Agricultural Research and Development Institute (Serdang, Malaysia).
- NBPGR: National Bureau of Plant Genetic Resources (New Delhi, India).
- NPGRL: National Plant Genetic Resources Laboratory, Institute of Plant Breeding (Los Baños, the Philippines).
- PAGV: Proefstation voor de Akkerbouw en de Groenteteelt in de Vollegrond (Lelystad, the Netherlands)
- PCARRD: Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (Los Baños, the Philippines).
- TISTR: Thailand Institute of Scientific and Technological Research (Bangkok, Thailand).
- UNITECH: Papua New Guinea University of Technology (Lae, Papua New Guinea).
- UPLB: University of the Philippines at Los Baños (Los Baños, the Philippines).
- USDA: United States Department of Agriculture (Washington D.C., United States).
- WAU: Wageningen Agricultural University (Wageningen, the Netherlands).

Glossary

abaxial: on the side facing away from the axis or stem (dorsal)

abortifacient: inducing abortion

abscission: the natural detachment of leaves, branches, flowers or fruits

accession: in germplasm collections: plant material of a particular collection, usually indicated with a number

accessory buds: those additional to the axillary and normal buds; more than one bud in an axil

accrescent: increasing in size with age

achene: a small dry indehiscent one-seeded fruit

acicular: needle-shaped; sharp pointed

actinomorphic: radially symmetrical; applied to flowers which can be bi-sected in more than one vertical plane

aculeate: furnished with prickles; prickly

acuminate: ending in a narrowed, tapering point with concave sides

acute: sharp; ending in a point with straight or slightly convex sides

adaxial: on the side facing the axis or stem (ventral)

adnate: united with another part; with unlike parts fused, e.g. ovary and calyx tube

adpressed (appressed): lying flat for the whole length of the organ

adventitious: not in the usual place, e.g. roots on stems, or buds produced in other than terminal or axillary positions on stems

air layering (marcotting): a form of layering in which soil (rooting medium) is brought to the branch to be layered; the ball of soil in a polyethylene cover is wrapped around the girdled branch; after adventitious roots grow out above the girdle, the layer can be separated

ala(e): wing(s), the lateral petal(s) of a papilionaceous flower

aliform: wing-shaped

alkaloid: large group of organic bases containing nitrogen and usually oxygen that occur for the most part in the form of salts with acids; usually optically and biologically active

allelopathy: the reputed baneful influence of one living plant upon another due to secretion of toxic substances

allopolyploid (alloploid): a polyploid with more than two sets of chromosomes, derived from different species; allotriploid with three sets, allotetraploid with four sets, etc

alluvium: soil material deposited by running water in recent geologic time

alternate: leaves, etc., inserted at different levels along the stem, as distinct from opposite or whorled

amphidiploid (amphiploid): a polyploid with a complete set of chromosomes from each parent, usually produced by doubling the chromosome number in the first generation hybrid

amplexicaul: stem-clasping, when the base of a sessile leaf or a stipule is dilated at the base, and embraces the stem

anaemia: a condition in which the blood is deficient in red blood cells, in haemoglobin, or in total volume

analeptic: restorative, especially a stimulant to the central nervous system

analgesic: producing insensibility to pain without loss of consciousness

andosol: a young volcanic soil originating from weathering of volcanic ash

androecium: the male element; the stamens as a unit of the flower

androgynophore: a column on which stamens and carpels are borne

androphore: a stalk supporting the androecium or stamens

anemophilous: wind-pollinated, the pollen being conveyed by the air

aneuploid: with other than the exact multiple of the haploid chromosome complement

annual: a plant which completes its life cycle in one year

anthelmintic: a drug or agent that destroys or causes expulsion of intestinal worms

anther: the part of the stamen containing the pollen

anthesis: the time the flower is expanded, or, more strictly, the time when pollination may take place

anthracnose: a disease characterized by distinctive limited lesions on stem, leaf or fruit, often accompanied by dieback

anticlinal: perpendicular to the surface

antrorse: directed upwards (opposed to retrorse)

apetalous: without petals or with a single perianth

apex (plural apices): tip or summit of an organ

aphrodisiac: a food or drug stimulating sexual desire

apical: at the point of any structure

apiculate: ending abruptly in a short point

apomict: an organism reproducing by apomixis

apomixis: reproduction by seed formed without sexual fusion (apomictic)

applanate: flattened out or horizontally expanded

appressed (adpressed): lying flat for the whole length of the organ

arborescent: attaining the size or character of a tree

arcuate: curved

aril: an expansion of the funicle enveloping the seed, arising from the placenta; sometimes occurring as a pulpy cover (arillus)

arillode: a false aril, any seed-coat not arising from the placenta

arilloid: like an aril

aristate: awned

arris: a sharp external angle formed by the meeting of two surfaces

arthritis: inflammation of a joint or joints

articulate: jointed, or with places where separation takes place naturally

articulation: a joint, popularly applied to nodes of grasses

ascending: curving or sloping upwards

asexual: sexless; not involving union of gametes

astringent: an agent or substance causing shrinkage of mucous membranes or raw or exposed tissues

atonic: characterized by a lack of tonus or vital energy; weakness, especially of a contractile organ

attenuate: gradually tapering

auricle: a small lobe or ear

auriculate: eared, having auricles

auriform: ear-shaped

autopolyploid (autoploid): polyploid with more than two sets of similar chromosomes derived from the same species

auxin: an organic substance characterized by its ability in low concentrations to promote growth of plant shoots and to produce other effects such as root formation and bud inhibition

awn: a bristle-like appendage, especially occurring on the glumes of grasses

axil: the upper angle between the leaf and the stem

axillary: arising from the axil

axis: the main or central line of development of a plant or organ

baccate: berrylike; pulpy or fleshy

barb: a hooked hair at the base of spikelets in some grasses

barbate: bearded, having long weak hairs in tufts

bark: the tissue external to the vascular cambium collectively, being the secondary phloem, cortex and periderm

basifixed: attached or fixed by the base

beak: a long, prominent and substantial point, applied particularly to prolongations of fruits

beaked: used of fruits which end in a long point

bearded: awned; having tufts of hairs

berry: a juicy indehiscent fruit with the seeds immersed in pulp; usually several-seeded without a stony layer surrounding the seeds

bidentate: having two teeth; doubly dentate, as when the marginal teeth are also toothed

bidenticulate: minutely bidentate

biennial: a plant which flowers, fruits and dies in its second year or season

bifid: cleft into two parts at the tip

bilabiate: two-lipped

biliousness: a situation marked or accompanied by disordered liver function due to or associated with excessive secretion of bile

bilocular: with two compartments or cells

binate: consisting of two members

biotype: a population or race in which all the individuals have the same genetic constitution

bipinnate: when the primary divisions (pinnae) of a pinnate leaf are themselves pinnate

bisexual: having both sexes present and functional in the same flower

blade (lamina): the expanded part of a leaf or petal

bract: a reduced leaf subtending a flower, flower stalk or (a part of an) inflorescence

bracteole: a secondary bract on the pedicel or close under the flower

bristle: a stiff hair or a hair-like stiff slender body

Brix: see degrees Brix

budding: the process of inserting a scion, which consists of the bud in a leaf axil on a shield of rind, with or without a small piece of wood attached, into a plant (rootstock) with the intention that it will unite and grow there, usually in order to propagate a desired cultivar

bulb: an underground storage organ with a much-shortened stem bearing fleshy leaf-bases or scale leaves enclosing the next year's bud
bulbil: an aerial bulb or bud produced in a leaf axil or replacing the flower, which, on separation, is capable of propagating the plant
bullate: surface much blistered or puckered
bunch: cluster, growing together
bush: a low thick shrub without a distinct trunk
butt: the base of a plant from which the roots spring
caducous: falling off early
caespitose: forming mats or spreading tufts
callus: tissue that forms over cut or damaged plant surface; small hard outgrowth at the base of spikelets in some grasses
calycle: a whorl of bracts outside the calyx simulating an additional calyx
calyx: the outer envelope of the flower, consisting of sepals, free or united
cambium (plural cambia): a layer of nascent tissue between the (sap)wood and bark, adding elements to both
campanulate: bell-shaped
canaliculate: channelled, with a longitudinal groove
capitate: headed, like the head of a pin in some stigmas, or collected into compact headlike clusters as in some inflorescences
capitellate: diminutive of capitate
capitulum: a dense inflorescence of an aggregation of usually sessile flowers, as in Compositae
capsule: a dry dehiscent fruit composed of two or more carpels and either splitting when ripe into valves, or opening by slits or pores
carcinogenic: producing or tending to produce cancer
carina: keel, the two inner united petals of a papilionaceous flower
carpel: one of the foliar units of a compound pistil or ovary; a simple pistil has only one carpel
caruncle (strophiole): an outgrowth of a seed near the hilum
caryopsis: the fruit of a grass, in which the outer layer (testa) of the seed proper is fused to the ovary wall
catarrh: inflammation of the lining tissue of various organs, particularly of the nose, throat, and air passages, and characterized by an outpouring of mucus
caudate: with a tail-like appendage
cauliflorous: flowers borne on the stem from the old wood, separate from the leaves
cauliflory: floral buds (flowers) borne on the trunk and larger (older) branches in positions where the leaves have already been shed
cauline: belonging to the stem or arising from it
chartaceous: papery
chlorophyll: green pigment in plants which absorbs light for photosynthesis
chromosome: a structural unit in the nucleus which carries the genes in a linear constant order; the number is typically constant in any species
ciliate: with a fringe of hairs along the edge
circumscissile: dehiscing or falling off along a circular line
clavate: club-shaped or thickened towards the end
claw: the narrow part of a petal or sepal
cleistogamous: pollination and fertilization taking place within the unopened flower
clone: a group of plants originating by vegetative propagation from a single plant and therefore of the same genotype
coherent: the incorporation of one part with another, as the petals to form a tubular corolla
colic: a paroxysm of acute abdominal pain localized in a hollow organ or tube and caused by spasm, obstruction, or twisting
colluvium: a heterogenous soil emplaced primarily by gravitational processes (also creek and slope wash) on or at the foot of slopes
column: a tube of connate stamen filaments
compatibility: in floral biology: capable of cross-fertilization or self-fertilization; in plant propagation: stock–scion combinations resulting in a lasting union
compound: of two or more similar parts in one organ, as in a compound leaf or compound fruit
concave: hollow
concolourous: similarly coloured on both sides or throughout; of the same colour as a specified structure
confluent: blended into one, passing by degrees from one into the other
conical: having the shape of a cone (cone-shaped)
conjugate: coupled
connate: united or joined
connivent: having a gradually inward direction, as in many petals (convergent)
conoidal: similar in shape to a geometrical cone
contorted: twisted or bent
convex: having a more or less rounded surface
cordate: heart-shaped, as seen at the base of a leaf, etc., which is deeply notched
cordiform: heart-shaped
coriaceous: of leathery texture
corm: a solid, short, swollen underground stem,

usually erect and tunicated, of one year's duration, with that of the next year at the top or close to the old one
corolla: the inner envelope of the flower existing of free or united petals
corona (crown, coronet): any appendage or extrusion that stands between the corolla and stamens (as in flowers of *Passiflora*)
corrugated: wrinkled
cortex: the bark or rind
cortical: relating to the cortex
corymb: a flat-topped indeterminate inflorescence in which the branches or pedicels sprout from different points, but attain approximately the same level, with the outer flowers opening first
corymbose: flowers arranged to resemble a corymb
cotyledon: seed-leaf, the primary leaf (dicotylous embryos have two cotyledons and monocotylous embryos have one)
crenate: the margin notched with blunt or rounded teeth
crenulate: crenate (scalloped), but the teeth themselves small
crescent-shaped: approximately the shape of a crescent (shape of thenew moon)
cross-pollination: placement of pollen from one flower on the stigma of a flower of another plant which is not of the same clone
crown: the aerial expanse of a tree, not including the trunk; corona; a short rootstock with leaves; the base of a tufted, herbaceous, perennial grass
crustaceous: of brittle texture
crystalline: of the nature of or relating to a crystal
culm: the stem of grasses and sedges
cultigen: a plant species or race that has arisen or is known only in cultivation
cultivar (cv., plural cvs): an agricultural or horticultural variety that has originated and persisted under cultivation, as distinct from a botanical variety. A cultivar name should always be written with an initial capital letter and given single quotation marks
cuneate: wedge-shaped; triangular, with the narrow end at the point of attachment, as the bases of leaves or petals
cusp: a sharp, rigid but small point
cuspidate: abruptly tipped with a sharp rigid point
cutting: the severed portion of a plant, used for propagation
cyme: a determinate inflorescence, often flat-topped, in which each growing point ends in a flower and the central flowers open first
cymose: bearing cymes or inflorescences related to cymes
cymule: a diminutive, usually few-flowered cyme or portion of one
cystolith: mineral concretions, usually of calcium carbonate on a cellulose stalk
cytoplasm: the protoplasm of a cell, excluding the nucleus
damping-off: a disease of seedlings or cuttings caused by fungi who cause various affects from germination failure to die off
deciduous: shedding or prone to shedding, applied to leaves, petals, etc.
decumbent: reclining or lying on the ground reclining or lying on the ground, but with the summit ascending
decurrent: extending down and adnate to the petiole or stem, as occurs in some leaves
decussate: of leaves, arranged in opposite pairs on the stem, with each pair perpendicular to the preceding pair
deflexed (reflexed): abruptly bent or curved downward or backward
degree-day: one degree-day is the difference between the average temperature and 13°C
degrees Brix: a measure of the total soluble solids in fruit juices; calibrated in terms of pure sucrose (e.g. 1° Brix = 1% sucrose), now used interchangeably with total soluble solids for fresh fruits and other fleshy parts
dehiscent: opening spontaneously when ripe, e.g., capsules, anthers
deltoid: shaped like an equal-sided triangle
dentate: margin prominently toothed with the pointed teeth directed outwards
denticulate: minutely toothed
depurative: removes impurities or waste materials; 'purifies' the blood
dermatitis: inflammation of the skin typically marked by reddening, swelling, oozing, crusting or scaling
determinate: of inflorescences, when the terminal or central flower of an inflorescence opens first and the prolongation of the axis is arrested; of shoot growth, when extension growth takes the form of a flush, i.e. only the previously formed leaf primordia unfold; for pulses also used to indicate bush-shaped plants with short duration flowering in one plane
diadelphous: in two bundles
dichasium (plural dichasia): a cymose inflorescence with 2 (nearly) equal lateral branches arising below the terminal flower, this pattern being repeated or not (compound and simple dichasium respectively)
dichogamy: prevention of natural self-pollination

in an individual flower by separation of pollen dehiscence and stigma receptivity in time

dicotyledon: angiosperm with two cotyledons or seed-leaves

didynamous: with the stamens in two pairs, two long and two short ones

digitate: a compound leaf whose leaflets diverge from the same point like the fingers of a hand

dimorphic: of two forms, as may occur with branches, etc

dioecious: with unisexual flowers and with the staminate and pistillate flowers on different plants (dioecy)

diploid: with two sets (genomes) of chromosomes, as occurs in somatic or body cells; usually written $2n$, having twice the basic chromosome number of the haploid germ cells

discoid: resembling a disk or discus, being flat and circular

discolourous: dissimilarly coloured on both sides or throughout; of a different colour as a specified structure

disk: a fleshy or elevated development of the receptacle within the calyx, corolla or stamens, often lobed and nectariferous

dissected: divided into many slender segments

distal: situated farthest from the place of attachment

distichous: regularly arranged in two opposite rows on either side of an axis

diuretic: an agent increasing the urinary discharge

dormancy: a term used to denote the inability of a resting plant or plant part (e.g. the seed, or in tree crops usually the buds) to grow or to leaf out even under favourable environmental conditions

dorsal: back; referring to the back or outer surface of a part or organ (abaxial)

dorsifixed: attached by the back, as in the case of the attachment of anthers to a filament

downy: covered with very short and weak soft hairs

dropsy: an abnormal accumulation of serous fluid in connective tissue, causing puffy swelling

drupaceous: resembling a drupe, whether actually a drupe or not

drupe: a fleshy one-seeded indehiscent fruit with the seed enclosed in a strong endocarp

ecotype: a biotype resulting from selection in a particular habitat

ecto-: in compositions, referring to the outside or the outer surface or part

edaphic: pertaining to or influenced by conditions of the soil

effused: expanded

egg: the female gamete or germ cell

ellipsoid: a solid which is elliptic in outline

elliptic(al): oval in outline but widest about the middle

emarginate: notched at the extremity

emasculate: to remove the anthers from a bud or flower before the pollen is shed

embryo: the rudimentary plant within a seed, developed from a zygote (sexual) or from other nuclei in the embryo sac or cells of the nucellus or integuments (apomictic)

emetic: an agent that induces vomiting induces vomiting

emmenagogue: substance promoting flow of menstrual discharge

emollient: soothes, softens, relaxes and protects the skin

endemic: exclusively native to a specified or comparatively small region; also used as a noun for a taxon thus distributed

endo-: in compositions, referring to the inside or the inner surface or part

endocarp: the innermost layer of the pericarp or fruit wall

endogenous: originating from within the organism

endosperm: the starchy or oily nutritive material stored within some seeds, sometimes referred to as albumen; it is triploid, having arisen from the triple fusion of a sperm nucleus and the two polar nuclei of the embryo sac

energy value: the heat produced by the combustion of a unit weight of a fuel

entire (botany): with an even margin without teeth, lobes, etc.

entomophilous: applied to flowers which are pollinated by insects

ephemeral: lasting for a day or less, e.g. certain inflorescences

epicalyx: an involucre of bracts below the flower, resembling an extra calyx

epicotyl: the young stem above the cotyledons

epiderm: the true cellular skin or covering of a plant below the cuticle

epidermoid: belonging to or resembling the epiderm

epigeal: above the ground (in epigeal germination the cotyledons are raised above the ground)

epipetalous: borne upon or placed in front of the petals

epiphyte: a plant that grows on another plant but without deriving nourishment from it

erect: directed towards summit, not decumbent

erecto-patent: between spreading and erect *ex situ:* in an artificial environment or unnatural habitat

exocarp: the outer layer of the pericarp or fruit wall

exsert, exserted: protrude beyond, as stamens beyond the tube of the corolla

exstipulate: without stipules

extra-axillary: beyond or outside the axil

extrorse: directed outward, as the dehiscence of an anther

F_1, F_2, etc.: symbols used to designate the first generation, second generation, etc., after a cross

falcate: sickle-shaped

fascicle: a cluster of flowers, leaves, etc., arising from the same point

febrifuge: an agent serving to reduce fever

ferralitic (of soil): deeply weathered reddish clayey soil rich in aluminium and iron ions

ferruginous: rust coloured

fertilization: union of the gametes (egg and sperm) to form a zygote

fibre: any long, narrow cell of wood or bast other than vessel or parenchym elements

fibrous: having much woody fibre

fig: the fleshy multiple fruit, derived from the inflorescence of *Ficus* spp. (syconium)

filament: thread; the stalk supporting the anther

filiform: slender; threadlike

fimbriate: fringed

flabellate: fan-shaped, dilated in a wedge-shape, sometimes plaited (folded)

flexuous, flexuose: zigzag; bent alternately in opposite directions

floccose: covered with dense hairs that fall away in tufts, locks or flocci

floret: a small flower, one of a cluster as in grasses or Compositae

flush: a brief period of rapid shoot growth, with unfolding of the leaf primordia which had accumulated during the previous quiescent period

foliaceous: leaf-like

foliolate (2-, 3-, 4- etc.): with 2-, 3-, 4- leaflets

follicle: a dry, unicarpellate fruit, dehiscing by the ventral suture to which the seeds are attached

frond: the foliage of ferns and other cryptogams; also used for the leaves of palms

fruit: the ripened ovary with adnate parts

funnelform: salver-shaped

fusiform: spindle-shaped; tapering, towards each end from a swollen centre

gamete: a unisexual protoplasmic body, incapable of giving rise to another individual until after conjugation with another gamete

gamopetalous: with united petals either throughout their length or at the base

gamosepalous: with united sepals either throughout their length or at the base

gene: the unit of inheritance located on the chromosome

genetic erosion: the decline or loss of genetic variability

genome: a set of chromosomes as contained within the gamete and corresponding to the haploid chromosome number of the species

genotype: the genetic makeup of an organism comprising the sum total of its genes, both dominant and recessive; a group of organisms with the same genetic

genus (plural genera): the smallest natural group containing distinct species

germplasm: the genetic material that provides the physical basis of heredity; also a collection of genotypes of an organism

glabrate: destitute of pubescence and of any roughness

glabrescent: becoming glabrous or nearly so

glabrous: devoid of hairs

glandular: having or bearing secreting organs or glands

glaucous: pale bluish-green, or with a whitish bloom which rubs off

globose: spherical or nearly so

glume (plural glumes): the shaffy or membranous two-ranked members of the inflorescence of grasses and similar plants; lower glume and upper glume, two sterile bracts at the base of a grass spikelet

glycosides: compounds that are acetal derivatives of sugars and that on hydrolysis yield one or more molecules of a sugar and often a noncarbohydrate

graft: a union of different individuals by apposition, the rooted plant being termed the stock, the portion inserted the scion

grafting: the process of inserting a scion, which consists of a piece of stem and two or more buds of the plant to be propagated, into another plant (rootstock) with the intention that it will unite and grow

granulose (granular): composed of or covered with grain-like minute particles

grumosol (vertisol): dark and heavy clay-rich soil type (40–80% montmorillonite) with well-developed horizons and a pH of 6–7.5 which generally occurs in areas with a pronounced dry season

gynoecium: the female part or pistil of a flower, consisting, when complete, of one or more ovaries with their styles and stigmas

gynophore: a stalk supporting the gynoecium formed by elongation of the receptacle
habit: external appearance or way of growth of a plant
habitat: the kind of locality in which a plant grows
haemorrhage: bleeding; an escape of blood from blood vessels
haploid: having a single set (genome) of chromosomes in a cell or an individual, corresponding to the chromosome number (n) in a gamete
harvest index: the total harvestable produce as a fraction of the total biomass produced by the crop in a given year
hastate: with more or less triangular basal lobes diverging laterally
head: a dense inflorescence of small crowded often stalkless flowers (capitulum)
hemi-: in compositions, half
herb: any vascular plant which is not woody
herbaceous: with the texture, colour and properties of a herb; not woody
heritability: the proportion of variability that results from genetic causes; also that proportion of the variation of a population that is transmitted to progeny
hermaphrodite: bisexual; in flowers, with stamens and pistil in the same flower
heterogamous: with two or more kinds or forms of flowers
heterostylous: having styles of two or more distinct forms or of different lengths
heterozygote: an organism with different genes at corresponding loci of homologous chromosomes; consequently producing unlike gametes
heterozygous: the condition in which homologous chromosomes of an individual possess different alleles at corresponding loci
hilum: the scar left on a seed indicating its point of attachment
hirsute: with rather coarse stiff hairs
hispid: covered with long rigid hairs or bristles
hispidulous: minutely hispid
homozygote: an individual whose homologous chromosomes carry identical genes at corresponding loci
homozygous: possessing identical genes at corresponding loci on homologous chromosomes
hull (husk): the outer covering of certain fruits or seeds
hyaline: almost transparant
hybrid: the first generation offspring of a cross between two individuals differing in one or more genes
hybridization: the crossing of individuals of unlike genetic constitution
hydrolysis: a chemical reaction of water in which a bond in the reactant other than water is split and hydrogen and hydroxyl are added
hypanthium: a cup-like receptacle usually derived from the fusion of the floral envelopes and androecium on which are seemingly borne the calyx, corolla and stamens
hypocotyl: the young stem below the cotyledons
hypogeal: below ground (in hypogeal germination the cotyledons remain below ground within the testa)
imbricate: overlapping like tiles; in a flower bud when one sepal or petal is wholly external and one wholly internal and the others overlapping at the edges only
imparipinnate: of leaves, pinnate with an unpaired terminal leaflet
in situ: in the natural environment
in vitro: outside the living body and in an artificial environment
inbred line: the product of inbreeding; a line originating by self-pollination and selection
inbreeding: breeding through a succession of parents belonging to the same stock
incompatibility: in floral biology: not capable of cross- or self-fertilization; in plant propagation: no stock–scion combinations resulting in a lasting union
indehiscent: not opening when ripe
indented: forced inward to form a depression
indeterminate: of inflorescences, a sequence in which the terminal flowers are the last to open, so that the floral axis may be prolonged indefinitely by the terminal meristem. Of shoot growth: when the shoot apex forms and unfolds leaves during extension growth, so that shoot growth can continue indefinitely
indigenous: native to a particular area or region
indumentum: a covering, as of hairs, scales, etc.
induplicate: with the margins bent inwards and the external face of these edges applied to each other without twisting
inferior: beneath, lower, below (an inferior ovary is one which is below the sepals, petals and stamens)
inflorescence: the arrangement and mode of development of the flowers on the floral axis
infrageneric: within a genus, e.g. a subdivision
infraspecific: within a species, e.g. variation
infructescence: a ripened inflorescence in the fruiting stage
inoculation: grafting, more properly budding, a single bud only being inserted; transferring e.g.

mycorrhiza or rhizobia in the growing medium to promote growth

inoculum: material used for inoculation, e.g. rhizobia in soil to promote the growth of certain Leguminosae

internode: the portion of the stem between two nodes

interpetiolar: of stipules placed between the petioles of opposite leaves

intrapetiolar: of stipules, positioned within the petiole axil

introrse: turned inward, towards the axis, as the dehiscence of an anther

involucral: belonging to an involucre

involucre: a ring of bracts surrounding several flowers or their supports, as in the heads of Compositae or the umbels in Umbelliferae

involute: having the edges of the leaves rolled inwards

irregular flower: in which parts of the calyx or corolla are dissimilar in size and shape; asymmetrical or zygomorphic

jugate: connected or yoked together; e.g. in leaves 1–n jugate: with 1–n pairs of leaflets

juvenile phase (stage): the period between germination and the first signs of flowering, during which vegetative processes preclude flower initiation even under the most favourable conditions

keel (carina): a ridge like the keel of a boat; the two anterior and united petals of a papilionaceous corolla; the principal nerve of a sepal or glume

keeled (carinate): having a keel or carina

kernel: the nucellus of an ovule or of a seed, that is, the whole body within the coats

labellum: lip; the lowest petal of an orchid

lacerate(d): torn, or irregularly cleft

lacinate: with narrow parted lobes

lamina (blade): the expanded part of a leaf or a petal

lanceolate: lance-shaped; much longer than broad being widest at the base and tapering to the apex

laterite: a red soil that shows intensive weathering and chemical change and leaching away of bases and silica leaving aluminium and iron oxides

latex: a juice, usually white and sometimes sticky, exuding from broken surfaces of some plants

laticiferous: latex-bearing

latosol: a leached red or yellow tropical soil

layer: a branch caused to root while still connected to the parent and used for propagation (layering)

leaching: of a soil, the removal of soluble and nutritive elements by a vertical, downward water movement

leaflet: one part of a compound leaf

lemma: the lower of the two membranous bracts enclosing the flower in grasses; the lower of the two glumes which surround each floret in the spikelet of grasses

leukemia: a disease of unknown cause that involves the blood-forming organs

ligulate: with or possessing a ligule

ligule: a membranous outgrowth on the upper surface of a grass leaf at the junction of the sheath and the blade. It may be presented by a ridge or by a line of hairs; an elongated flattened strap-shaped structure

limb: the expanded part of a tubular corolla, as distinct from the tube or throat; the lamina of a leaf or of a petal

linear: long and narrow with parallel sides

lobe: any division of an organ or specially rounded division

lobed: of leaves, divided, but not to the base

locular: divided by internal partitions into compartments as in anthers and ovaries

locule: the cavity of an ovary or anther

loculicidal: the cavity of a pericarp dehiscent by the back, the dorsal suture

longitudinal: lengthwise

lyrate: of a leaf with small pinnate lobes below and a larger terminal lobe

Malesia: the bio-geographical region including Malaysia, Indonesia, the Philippines, Singapore, Brunei and Papua New Guinea

mangrove: a brackish-water coastal swamp of tropical and subtropical areas that is partly inundated by tidal flow

marcotting (air layering): a form of layering in which soil (rooting medium) is brought to the branch to be layered; the ball of soil in a polyethylene cover is wrapped around the girdled branch; after adventitious roots grow out above the girdle, the layer can be separated

marginate: furnished with a margin of distinct character

meiosis: nuclear divisions in which the diploid chromosome number is reduced to half that of the parent cell to give the haploid number, as in gametes

membranous: thin and semi-transparant, like a fine membrane

mericarp: one of the separate halves or parts of a fruit, as in Umbelliferae

meristem: undifferentiated tissue of the growing point whose cells are capable of dividing and developing into various organs and tissues

merous (4–, 5– etc.): with 4, 5 etc. parts or numbers of sepals, petals etc.

mesocarp: the middle layer of the pericarp or fruit wall which is often fleshy or succulent

metabolism: the chemical changes in living cells by which energy is provided for the vital processes and activities, and new material is assimilated to repair the waste

metabolite: a substance essential to the metabolism of a particular organism or to a particular metabolic process

midrib: the main vein of a leaf which is a continuation of the petiole

mildew: a superficial, usually whitish growth on living plants produced by fungi

monadelphous: of stamens, united into one group by their filaments

monocarpic: only flowering and fruiting once (said of an annual or other plant)

monochasium: a cymose inflorescence where a pattern of a single lateral branch arising below the terminal flower is repeated

monocotyledon: angiosperm having a single cotyledon or seed-leaf

monoecious: with unisexual flowers, but male and female flowers borne on the same plant

monophyletic: of a group of taxa, a natural one which includes the known or hypothesized common ancestor and all of its descendants

monopodial: of a primary axis which continues its original line of growth from the same apical meristem to produce successive lateral branches

morphotype: a special form of a plant species, usually only slightly differing from the normal habit

mucilage: a gelatinous substance that is similar to gum but that swells in water without dissolving and forms a slimy mass

mucous: secreting or containing a viscous or slimy matter

mucro: a sharp terminal point

mucronate: ending abruptly in a short stiff point

mucronulate: diminutive of mucronate

muricate: rough, with short and hard tubercular excrescences

mycorrhiza: a symbiotic association of roots with a fungal mycelium which may form a layer outside the root (ectotrophic) or within the outer root tissue (endotrophic)

naturalized: introduced into a new area and established there, giving the impression of wild growth

necrosis: death of a portion of tissue often characterized by a brown or black discoloration

nectary: a group of modified subepidermal cells in flowers or leaves (extrafloral) secreting nectar

nematode: small elongated cylindrical worm-like micro-organism, free-living in soil or water, or parasitic in animals or plants

nerve: a strand of strengthening and/or conducting tissue running through a leaf, which starts from the midrib and diverges or branches throughout the blade

neuter: sexless, neither male or female; having neither functional stamens nor pistils

node: the point on the stem or branch at which a leaf or branch is borne

nodulation: formation of root-nodules

nodule: a small knot or rounded body, often in roots of leguminous plants, where bacteria of the genus *Rhizobium* are active in the fixation of nitrogen from the air

nut: a one-seeded indehiscent fruit with a hard dry pericarp or shell

nutlet: a little nut

ob-: the inverse or opposite condition (obtriangular, obcordate, etc.)

oblate: flattened at the poles

oblique: slanting; of unequal sides

oblong: longer than broad, with the sides parallel or almost so

oblongoid: a solid object which is oblong in section

obovate: reverse of ovate

obovoid: solid and reversely egg-shaped

obtuse: blunt or rounded at the end

operculum: a lid or cover which separates by a transverse line of division

opposite: of leaves and branches when two are borne at the same node on opposite sides of the stem

orbicular: flat with a more or less circular outline

orthotropic: having a more or less vertical direction of growth

outcross: cross-pollination, usually by natural means, with plants differing in genetic constitution

ovary: that part of the pistil, usually the enlarged base, which contains the ovules and eventually becomes the fruit

ovate: egg-shaped in outline; a flat surface which is scarcely twice as long as broad with the widest portion below the middle

ovoid: solid and egg-shaped

ovule: the immature seeds in the ovary before fertilization

p.v.: see physiological varieties (races)

palea: the upper of two membranous bracts enclosing the flower in grasses
palmate: of leaflets, leaf-lobes or nerves, with the different elements arising from the same point
palmatifid: cut about half way down in a palmate manner
panicle: an indeterminate branched racemose inflorescence
paniculate: resembling a panicle
pantropical: distributed throughout the tropics
papillose: covered with minute nipple-like protuberances
pappus: the various tufts of hairs on achenes or fruits; the limb of the calyx of Compositae florets
parasitic: deriving nourishment from some other organism
parenchyma: tissue composed of more or less isodiametric cells, e.g. the pith and mesophyll
paripinnate: a pinnate leaf with all leaflets in pairs
parthenocarpy: the production of fruit without true fertilization
partite: cleft nearly, but not quite to the base
patent: spreading out widely
pedicel: stalk of each individual flower of an inflorescence
pedicellate: borne on a pedicel
peduncle: the stalk of an inflorescence or partial inflorescence
pellucid: translucent
peltate: of a leaf with the stalk attached to the lower surface, not at the edge
pendent, pendulous: drooping; hanging down from its support
penninerved: pinnately veined, parallel veins arise at an angle from a midvein (as in *Musa*)
perennial: a plant living for many years and usually flowering each year
perfoliate: of a sessile leaf or bract whose base completely surrounds the stem
perianth: the floral leaves as a whole, including both sepals and petals if both are present
pericarp: the wall of the ripened ovary or fruit whose layers may be fused into one, or may be more or less divisible into exocarp, mesocarp and endocarp
perisperm: the nutritive tissue of some seeds derived from the nucellus
petal: a member of the inner series of perianth segments which are often brightly coloured
petaloid: petal-like
petiolar: borne on, or pertaining to a a petiole
petiolate: having a petiole
petiole: the stalk of a leaf
petiolule: the stalk of a leaflet
phenology: the complex annual course of flushing, quiescence, flowering, fruiting and leaf fall in a given environment
phenotype: the physical or external appearance of an organism as distinguished from its genetic constitution (genotype); a group of organisms with similar physical or external make-up
phloem: the principal food-conducting tissue of vascular plants; the bast element of a vascular bundle and basically composed of sieve elements, parenchyma cells, fibres and sclereids
photoperiod: length of day favouring optimum functioning of an organism
photosensitive: sensitive to the action of radiant energy such as light
phyllode: a petiole taking on the form and functions of a leaf
phyllody: transformation of flower parts into leaves
phyllotaxis: the arrangement of leaves or floral parts on an axis or stem
phylogenetic: based on natural evolutionary and genealogic relationships
physiological varieties (races): pathogens of the same species which are structurally similar, but which differ in physiological and pathological characteristics
pileate: having the form of a cap
pilose: hairy with rather long soft hairs
pilosity: hairiness
pinna (plural pinnae): a primary division or leaflet of a pinnate leaf
pinnate: arranged in pairs along each side of a common axis
pinnatifid: with the margin pinnately cleft
pinnatilobed: pinnately divided to about half-way to the midrib
pistil: the female part of a flower (gynoecium) of one or more carpels, consisting, when complete, of ovary(s), style(s) and stigma(s).
pistillate: a unisexual flower with pistil, but no stamens
pistillode: a sterile, often reduced pistil
placenta: the part of the ovary to which the ovules are attached
plagiotropic: having an oblique or horizontal direction of growth
plicate: folded to and fro, like a fan
plumose: featherlike with fine hairs, as on the sides of some bristles
plumule: the primary bud of an embryo or germinating seed

pneumatophore: used of air vessels of any description; a root often functioning as a respiratory organ in a marsh plant

pod: a general term for a dry dehiscent fruit

pollen: spores or grains borne by the anthers containing the male element (gametophyte)

pollination: the transfer of pollen from the dehiscing anther to the receptive stigma

polygamous: with unisexual and bisexual flowers in the same plant

polymorphic: polymorphous, with several or various forms; variable as to habit

polypetalous: with a corolla of separate petals

polyphyletic: of a group of taxa, a non-natural one in which the most recent common ancestor of all taxa is assigned to another group, the characterization of the group being based on convergent similarity

polyploid: an organism with more than two sets (genomes) of chromosomes in its somatic cells

pome: a fruit of which the apple is the type, resulting from a multi-locular inferior ovary imbedded in a fleshy receptacle

posterior: next to or towards the main axis

poultice: a soft, usually heated and sometimes medicated mass spread on cloth and applied to sores or other lesions

precocious: exceptionally early in development; flowering and fruiting at an early age

primordial: first in order of appearance

primordium: a group of undifferentiated meristematic cells, usually of a growing point, capable of differentiating into various kinds of organs or tissues

procumbent: lying along the ground

prop roots: aerial roots

propagule: a part of a plant that becomes detached and grows into a new plant

prophyll: the bracteole at the base of an individual flower

prostrate: lying flat on the ground

protandrous: stamens shedding pollen before the stigma is receptive

protogynous: the stigma being receptive before the pollen is shed

provenance: a collection of pollen, seed or propagules from a certain restricted locality

proximal: the part nearest the axis (as opposed to distal)

pruning: cutting off the superfluous branches or shoots of a plant for better shaped or more fruitful growth

pseudoraceme: raceme-like inflorescence but not a true raceme

puberulent: covered with down or fine hairs

puberulous: minutely pubescent

pubescent: covered with soft short hairs

pulses: dry edible seeds of legumes

pulvinate: cushion-shaped

pulvinule: the swollen base of a petiolule

pulvinus: a minute gland or swollen petiole base.

punctate: marked with dots or translucent glands

punctiform: in the form of a point or dot

pungent: bearing a sharp point; causing a sharp or irritating sensation

purgative: a medicine causing vigorous evacuation from the bowels

quadrate: approximately square or cubical

qualitative short-day plant: to flower, the plant needs short days (often with quantitative response); if the daylength surpasses a certain value (the critical daylength) the plant does not flower

quantitative short-day plant: plant flowers sooner under short-day conditions, but short days are not absolutely necessary to flower

raceme: an unbranched elongated indeterminate inflorescence with stalked flowers opening from the base upwards

racemose: raceme-like

rachilla: a diminutive or secondary axis, as the stalk of the spikelet in grasses

rachis (plural rachides): the principal axis of an inflorescence or a compound leaf

radical: arising from the root, or its crown

radicle: the first root of an embryo or germinating seed

ramiflorous: flowering on the branches

ramiflory: flowers borne on the larger branches and leafless twigs, but not on the trunk

ratoon: shoots left on the plants after harvest to produce the subsequent crop (ratoon crop)

ray: the radiating branch of an umbel; the outer floret of an inflorescence of the Compositae with straplike perianth which differs from those in the centre or disk

receptacle: the flat, concave or convex part of the axis from which the parts of the flower arise

recombination: new gene combination as a result of cross-fertilization between individuals differing in genotype

recumbent: lying down

recurved: bent or curved downward or backward

reflexed (deflexed): abruptly bent or curved downward or backward

reniform: kidney-shaped

resin: solid to soft semisolid amorphous fusible flammable substance obtained as exudate or as an extract of plants

reticulate: netted, as when the smallest veins of a leaf are connected together like the meshes of a net

retrorse: turned or directed backward or downward (opposed to antrorse)

retuse: with a shallow notch at a rounded apex

revolute: of leaf margins, rolled downwards towards the midrib

rhizobia: bacteria of the genus Rhizobium capable of forming symbiotic nodules on the roots of leguminous plants and able to fix atmospheric nitrogen

rhizome (rootstock): an underground stem which is distinguished from a root by the presence of nodes, buds, and leaves or scales

rhombic: shaped like a rhomb, an equilateral oblique-angled figure

rhomboid (botany): quadrangular, diamond-shaped with the lateral angles obtuse

root-nodules: small dwellings on roots of leguminous and other plants, containing nitrogen-fixing bacteria (rhizobia)

rootstock (rhizome): an underground stem which is distinguished from a root by the presence of nodes, buds, and leaves or scales

rosette: a cluster of leaves or other organs in a circular form

rostrate: beaked

rotate: wheel-shaped; circular and flat

rotund: rounded in outline, somewhat orbicular, but a little inclined towards oblong

rudimentary: of organs which are imperfectly developed and nonfunctional

rugose: wrinkled

rugulose: somewhat wrinkled

runner: a specialized stem that develops from a leaf axil at the crown of a plant, grows horizontally along the ground, and forms a new plant at one of the nodes, usually at or near the tip

saccate: pouched

sagittate: shaped like an arrowhead; of a leaf-base with two acute straight lobes directed downwards

saponin: a glycoside with soap properties

saprophyte: a plant which derives its food from dead organic matter

sarcotesta: the fleshy outer seed-coat

scabrid (scabrous): rough to the touch

scandent: climbing

scape: a leafless floral axis or peduncle arising from the ground

scarification (seed): scarifying, to cut or soften the wall of a hard seed to hasten germination

scarify: to treat a hard-coated seed by mechanical abrasion or with acid to facilitate germination

schizocarp: a pericarp which splits into one-seeded portions, mericarps or 'split fruits'

scion: the plant being propagated vegetatively in graftage; the part of the plant above the graft union

secondary nervation (secondary venation): the collection of veins of a leaf blade branching off from the main (primary) vein(s)

section (botany): a taxonomic rank between the genus and the species accommodating a single or several related species

sedative: a drug that tends to calm, moderate or tranquillize nervousness or excitement tending to calm, moderate or tranquilize

seed: the reproductive unit formed from a fertilized ovule, consisting of embryo and seed-coat, and, in some cases, also endosperm

seedling: the juvenile plant, grown from a seed

self-compatible (self-fertile): capable of fertilization and setting seed after self-pollination

self-pollination: pollination with pollen from the same flower or from other flowers of plants of the same clone

self-sterile: failure to complete fertilization and obtain seed after self-pollination

semi-: in compositions, half; incompletely, e.g. semi-inferior

senescence: advancing in age

sepal: a member of the outer series of perianth segments

sepaloid: sepal-like

septate: divided by one or more partitions

septum (plural septa): a partition or cross-wall

seriate: serial, disposed in series of rows

sericeous: silky

serrate: toothed like a saw, with regular pointed teeth pointing forwards

serrulate: serrate with minute teeth

sessile: without a stalk

seta(e): a bristle-like body

setose: set with bristles or bristle-like elements

setulose: set with small bristles or bristle-like elements

sheath: a tubular structure surrounding an organ or part, as the lower part of the leaf clasping the stem in grasses

shrub: a woody plant branching from the base, all branches being equivalent

siliceous: containing silica

silique: a dry and many-seeded dehiscent fruit splitting into 2 valves with a false partition

simple (botany): not compound, as in leaves with a single blade

spadix: a flower spike with a fleshy or thickened axis, as in aroids and some palms
spathate: furnished with a spathe
spathe: a large bract enclosing a spadix, or two or more bracts enclosing a flower cluster
spathulate: spoon-shaped
spherical: globular
spicate: spike-like
spiciform: spike-like
spicule: a fine, fleshy erect point
spike: a simple indeterminate inflorescence with sessile flowers along a single axis
spikelet: a secondary spike, one of the units of which the inflorescence is made in grasses, consisting of one or more florets on a thin axis, subtended by a common pair of glumes
spine: a short stiff straight sharp-pointed hard structure arising from the wood of a stem
spinescent: ending in a spine or sharp point
spinose: having spines (spinous)
spinulescent: slightly spiny or having small spines
spinulose: with small spines
spiral: as though wound round an axis
spur (botany): a hollow and slender extension of some part of the flower, usually nectariferous; a small reproductive shoot
stamen: one of the male reproductive organs of a flower; a unit of the androecium
staminate: of a flower, bearing stamens but no pistil
staminode: an abortive or rudimentary stamen without a perfect anther
staminophore: an often thickened structure on which the stamens are inserted
standard (flower part): the fifth, posterior or upper petal of a papilionaceous corolla (vexillum)
stellate: star-shaped, as of hairs with radiating branches
stem: the main ascending axis of a plant
sterile: failing to complete fertilization and produce seed as a result of defective pollen or ovules; not producing seed capable of germination; lacking functional sexual organs (sterility)
stigma: the portion of the pistil which receives the pollen
stilt roots: the oblique adventitious roots of the mangrove and similar forms
stipe: the stalk supporting a carpel or gynoecium
stipel: small secondary stipule at the base of a leaflet
stipitate: borne on a stipe or short stalk
stipulate: with or bearing stipules
stipule: a scale-like or leaf-like appendage at the base of a petiole
stolon: a trailing stem usually above the ground which is capable of producing roots and shoots at its nodes
stoloniferous: bearing a stolon or stolons
strain: a group of individuals of a common origin, usually a more narrowly defined group than a cultivar
striate: marked with fine longitudinal parallel lines, as grooves or ridges
strigillose: covered with minute stiff hairs
strigose: with short stiff hairs lying close along the surface
strophiole (caruncle): an outgrowth of a seed near the hilum
style: the part of the pistil connecting the ovary with the stigma
sub-: somewhat or slightly, e.g. subacute
subglobose: nearly globular
subspecies: a subdivision of a species, in rank between a variety and a species
subulate: awl-shaped
subverticillate: in imperfect or irregular whorls
succulent: juicy, fleshy
sucker: a shoot, usually originating from adventitious buds on the roots or basal stem parts, which does not fit in the architectural model, but is capable of repeating the model
sulcate: grooved or furrowed
superior (ovary): an ovary with the perianth inserted below or around its base, the ovary being attached at its base only
sutural: relating to a suture
suture: the line of junction of two carpels; the line or mark of splitting open
sympetalous: with united petals
sympodial: of a stem in which the growing point either terminates in an inflorescence or dies, growth being continued by a new lateral growing point
syncarp: a multiple or fleshy aggregate fruit, including fruit produced from a more or less entire inflorescence
syncarpous: of an ovary composed of two or more united carpels
taproot: the primary descending root, forming a direct continuation of the radicle
taxon (plural taxa): a term applied to any taxonomic unit irrespective of its classification level, e.g. variety, species, genus
tendril: a thread-like climbing organ formed from the whole or part of a stem, leaf or petiole
tepal: a segment of a perianth, applied when no distinction between sepal and petals can be made

terete: cylindrical; circular in transverse section
tertiary nerve: see tertiary venation
tertiary nervation (tertiary venation): generally the collection of the smallest veins of a leaf-blade
tessellate: marked with a fine chequered pattern, like a mosaic
testa: the outer coat of the seed
tetraploid: having four times ($4n$) the basic number of chromosomes or twice the diploid number ($2n$)
thallus: a vegetative body without differentiation into stem and leaf
theca (plural thecae): a spore- or pollen-case
thyrse: a compound inflorescence composed of a panicle (indeterminate axis) with the secondary and ultimate axes cymose (determinate)
thyrsiform: shaped like a thyrse
thyrsoid: like a thyrse
tiller: a shoot from the axils of the lower leaves, as in some grasses
tilth: surface soil prepared for planting or cultivation
tissue culture: a body of tissue growing in a culture medium outside the organism
tomentellous: minutely tomentose
tomentose: densely covered with short soft hairs
tonic(um): medicinal preparation believed to have the power of restoring normal activity
tortuous: bent or twisted in different directions
trailing: prostrate, but not rooting
transverse: of tertiary nerves, connecting the secondary nerves, not necessarily in a perpendicular way
tree: a perennial woody plant with a single evident trunk
tribe (plural tribae): a taxonomic rank between the family and the genus
trichome: any hair, bristle or scale-like outgrowth of the epidermis
trichotomous: three-forked, branching into three divisions
trifoliate: three-leaved
trifoliolate: with three leaflets
trigonous: three-angled, with plane faces
triploid: having three times the basic number of chromosomes, usually written $3n$
truncate: cut off more or less squarely at the end
trunk: the main stem of a tree apart from its limbs and roots
tuber: the swollen portion of an underground stem or root which acts as a storage organ and propagule; it is usually of one year's duration, those of successive years not arising directly from the old ones nor bearing any constant relation to them
tubercle: a small tuber-like excrescence
tuberculate: covered with warty protuberances
tuberiform: resembling a tuber
tuberous: producing tubers or resembling a tuber
tufted: growing in tufts (caespitose)
tunic: the coat of a bulb
tunicated: provided with a dry papery covering round a bulb or corm
turbinate: top-shaped
twining: winding spirally
umbel: an indeterminate, often flat-topped inflorescence whose divergent peduncles (rays) and pedicels arise from a common point; in a compound umbel each ray itself bears an umbel
umbelliform: umbrella-shaped
uncinate: hooked
uncinulate: diminutive of uncinate
undulate: wavy, said for instance of a leaf margin if the waves run in a plane at right angles to the plane of the leaf-blade
unifoliolate: with one leaflet only, but in origin a compound leaf
unisexual: of one sex, having stamens or pistils only
urceolate: urn-shaped
valvate: of perianth segments with their edges in contact, but not overlapping in the bud
valve: one of the parts produced by a dehiscing capsule; in grasses the glume next to the flower
variety: botanical variety which is a subdivision of a species; an agricultural or horticultural variety is referred to as a cultivar
vein: a strand of vascular tissue in a flat organ, such as a leaf
velutinous: velvety; with a coating of fine soft hairs; the same as tomentose but denser so that the surface resembles (and feels like) velvet
venation: the arrangement of the veins in a leaf
ventral: faces central axis (adaxial), opposed to dorsal
venulose: profusely veined
vermicidal: having the property of killing worms, especially intestinal worms
vermifuge: a drug serving to destroy or expel parasitic worms of the intestine
vernalization: the treatment of seeds or bulbs before planting to hasten flowering
verrucose: warty
verruculose: very warty, much covered with warts
verticil: whorl
verticillate: in a whorl with several elements arising at the same node

vertisol (grumosol): dark and heavy clay-rich soil type (40–80% montmorillonite) with well-developed horizons and a pH of 6–7.5 which generally occurs in areas with a pronounced dry season

vexillum (standard): the fifth, posterior or upper petal of a papilionaceous corolla

villose: with long weak hairs

vine: a plant having a stem that is too slender to hold itself erect and therefore supports itself by climbing over an object

viny: trailing or climbing

viviparous: germinating or sprouting from seed or bud while attached to the parent plant

warty: covered with firm roundish excrescences

whorl: more than two organs of the same kind arising at the same level

wing: any membraneous expansion attached to an organ; a lateral petal of a papilionaceous corolla

xerophytic: relating to a plant structurally adapted for life and growth with a limited water supply

zygomorphic: irregular flowers divisible into equal halves in one plane only

zygote: the cell formed from the fusion of two gametes; a fertilized egg

Sources of illustrations

Abelmoschus caillei: Westphal, E. & Jansen, P.C.M. (Editors), 1989. Plant Resources of South-East Asia. A selection. Pudoc, Wageningen. p. 25.

Abelmoschus esculentus: Westphal, E. & Jansen, P.C.M. (Editors), 1989. Plant Resources of South-East Asia. A selection. Pudoc, Wageningen. p. 25.

Abelmoschus manihot: Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 469 & 471, Figs. 292 & 294. Redrawn and adapted by Achmad Satiri Nurhaman.

Allium ampeloprasum cv. group Leek: Nicholson, B.E., Harrison, S.G., Masefield, G.B. & Wallis, M., 1969. The Oxford book of food plants. Oxford University Press, United Kingdom. p. 169, Fig. 2 (habit); Siemonsma, J.S. & van den Bergh, M.H., 1990. Collection of photographs (habit cv. group Prei Anak). Redrawn and adapted by P. Verheij-Hayes.

Allium cepa cv. group Aggregatum: Purseglove, J.W., 1972. Tropical crops. Monocotyledons. Longman, London, United Kingdom. Vol. 1. p. 39, Fig. 4 (flowering plants, inflorescence); Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. p. 389, Fig. 113 (mature bulbs). Redrawn and adapted by Iskak Syamsudin.

Allium cepa cv. group Common Onion: Langer, R.H.M. & Hill, G.D., 1982. Agricultural plants. Cambridge University Press, United Kingdom. p. 130, Fig. 4.1 (habit); Takii Seed. Vegetable catalog No 8, Kyoto, Japan (basal part of plant with mature bulb); de Wilde-Duijfjes, B.E.E., 1976. A revision of the genus Allium L. (Liliaceae) in Africa. Meded. Landbouwhogeschool Wageningen 76-11. p. 85, Fig. 14 (flowering plant). Redrawn and adapted by Achmad Satiri Nurhaman.

Allium chinense: Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. p. 456, Fig. 282 (habit after tillering); Siemonsma, J.S. & van den Bergh, M.H., 1990. Collection of photographs (mature bulbs). Redrawn and adapted by Iskak Syamsudin & P. Verheij-Hayes.

Allium fistulosum: de Wilde-Duijfjes, B.E.E., 1976. A revision of the genus Allium L. (Liliaceae) in Africa. Meded. Landbouwhogeschool Wageningen 76-11. p. 88, Fig. 15. Redrawn and adapted by Achmad Satiri Nurhaman.

Allium sativum: Purseglove, J.W., 1972. Tropical crops. Monocotyledons. Longman, London, United Kingdom. Vol. 1. p. 55, Fig. 6 (habit); Nicholson, B.E., Harrison, S.G., Masefield, G.B. & Wallis, M., 1969. The Oxford book of food plants. Oxford University Press, United Kingdom. p. 169, Fig. 3 (bulb, plantlets, inflorescence). Redrawn and adapted by Iskak Syamsudin.

Allium tuberosum: Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. p. 450, Fig. 278 (habit after tillering); Siemonsma, J.S. & van den Bergh, M.H., 1990. Collection of photographs (young inflorescences). Redrawn and adapted by Achmad Satiri Nurhaman.

Amaranthus tricolor: Westphal, E. & Jansen, P.C.M. (Editors), 1989. Plant Resources of South-East Asia. A selection. Pudoc, Wageningen. p. 35.

Apium graveolens: Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. p. 127, Fig. 2 (habit leaf celery); Nicholson, B.E., Harrison, S.G., Masefield, G.B. & Wallis, M., 1969. The Oxford book of food plants. Oxford University Press, United Kingdom. pp. 149 & 175, Figs. 1 & 3 (habit stalk celery, habit celeriac). Redrawn and adapted by P. Verheij-Hayes.

Archidendron jiringa: Koorders, S.H., 1926. Exkursionsflora von Java. Vol. 4, Atlas. p. 868, Fig. 1156 (habit); Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. p. 425, Fig. 264 (flowering and fruiting shoot); living material (germinating seed). Redrawn and adapted by Iskak Syamsudin.

Asparagus officinalis: Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. p. 457, Fig. 283 (leafy shoot); Wagenvoort, H. & de Geus, M., 1983. Grenzeloze groenten. KIM Natuurboeken, Baarn, the Netherlands. p. 10 (flowering shoot, fruiting shoot); Nicholson, B.E., Harrison, S.G., Masefield, G.B. & Wallis, M., 1969. The Oxford book of food plants. Oxford University Press, United Kingdom. p. 163, Fig. 3 (crown with spears). Redrawn and adapted by Achmad Satiri Nurhaman.

Basella alba: Department of Tropical Crop Science, Wageningen Agricultural University, the Netherlands. Original drawing by P. Verheij-Hayes.

Benincasa hispida: Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. p. 183, Fig. 112 (flowering and fruiting shoot); Brown, W.H., 1941–1943. Useful plants of the Philippines. Department of Agriculture and Natural Resources. Technical Bulletin 10. Bureau of Printing, Manila, the Philippines. Vol. 3. p. 360, Fig. 135 (female flower, male flower). Redrawn and adapted by Iskak Syamsudin.

Beta vulgaris: Nicholson, B.E., Harrison, S.G., Masefield, G.B. & Wallis, M., 1969. The Oxford book of food plants. Oxford University Press, United Kingdom. p. 171, Fig. 1 (habit cv. group Garden Beet); Hegi, G., 1979. Illustrierte Flora von Mitteleuropa. 2nd edition. Verlag Paul Parey, Berlin, Germany. Vol. 3(2). p. 552, Fig. 252 (inflorescence). Redrawn and adapted by P. Verheij-Hayes.

Brassica juncea: Hegi, G., 1986. Illustrierte Flora von Mitteleuropa. 3rd edition. Verlag Paul Parey, Berlin, Germany. Vol. 4(1). p. 438, Fig. 255 (flowering and fruiting shoot, seed); Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. p. 165, Fig. 100 (habit cv. group Broad-leaf Mustard); Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. p. 215, Fig. 39 (habit cv. group Head-leaf Mustard). Redrawn and adapted by P. Verheij-Hayes.

Brassica oleracea cv. groups Cauliflower & Broccoli: Nicholson, B.E., Harrison, S.G., Masefield, G.B. & Wallis, M., 1969. The Oxford book of food plants. Oxford University Press, United Kingdom. p. 159, Fig. 1 (habit cauliflower, flowerhead cauliflower); Voskuil, J., 1983. Zaai en plant gids voor de moestuin. Thieme, the Netherlands. p. 37 (flowerhead sprouting broccoli). Redrawn and adapted by P. Verheij-Hayes.

Brassica oleracea cv. group Chinese Kale: Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. p. 194, Fig. 29. Redrawn and adapted by Achmad Satiri Nurhaman.

Brassica oleracea cv. group Kohlrabi: Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. p. 189, Fig. 28. Redrawn and adapted by Iskak Syamsudin.

Brassica oleracea cv. group White Headed Cabbage: Hegi, G., 1986. Illustrierte Flora von Mitteleuropa. 3rd edition. Verlag Paul Parey, Berlin, Germany. Vol. 4(1). p. 445, Fig. 259. Redrawn and adapted by Achmad Satiri Nurhaman.

Brassica rapa cv. group Caisin: Herbarium Bogoriense, CRDB-LIPI, Bogor, Indonesia. Original drawing by Iskak Syamsudin.

Brassica rapa cv. group Chinese Cabbage: Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 197 & 198, Figs. 30 & 31 (habit, head); Asian Vegetable Research and Development Center, Shanhua, Tainan, Taiwan (flowering shoot). Redrawn and adapted by Achmad Satiri Nurhaman.

Brassica rapa cv. group Pak Choi: Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. p. 202, Fig. 34. Redrawn and adapted by P. Verheij-Hayes.

Brassica rapa cv. group Vegetable Turnip: Nicholson, B.E., Harrison, S.G., Masefield, G.B.

& Wallis, M., 1969. The Oxford book of food plants. Oxford University Press, United Kingdom. p. 173, Fig. 1. Redrawn and adapted by Iskak Syamsudin.

Canavalia gladiata: Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 234 & 235, Figs. 49 & 50. Redrawn and adapted by Achmad Satiri Nurhaman.

Capsicum annuum: Asian Vegetable Research and Development Center, Shanhua, Tainan, Taiwan. Original drawing by Min-Hsiung Yang. Redrawn and adapted by Jitno Rijadi.

Chrysanthemum coronarium: Valdés, B., Talavera, S. & Fernández-Galiano, E. (Editors), 1987. Flora vascular de Andalucía Occidental. Ketres Editora, Barcelona, Spain. Vol. 3. p. 64. Redrawn and adapted by Achmad Satiri Nurhaman.

Cichorium endivia: Hegi, G., 1929. Illustrierte Flora von Mitteleuropa. 1st edition. Lehmanns Verlag, München, Germany. Vol. 6(2). p. 999, Fig. 688. Redrawn and adapted by Achmad Satiri Nurhaman.

Citrullus lanatus: Museum of Natural History, University of the Philippines at Los Baños, College, Laguna, the Philippines. Original drawing by R.D. Tandang. Redrawn and adapted by P. Verheij-Hayes.

Cleome gynandra: Backer, C.A., 1928–1934. Onkruidflora der Javasche suikerrietgronden. Handboek ten dienste van de suikerriet cultuur en de rietsuiker fabricage op Java. Vereniging het Proefstation voor de Java-Suikerindustrie. Vol. 7, Atlas. Fig. 263. Redrawn and adapted by Iskak Syamsudin.

Coccinia grandis: Backer, C.A., 1973 (edited by van Steenis, C.G.G.J.). Weed flora of Javanese sugar-cane fields. Handbook for the cultivation of sugar-cane and manufacturing of cane-sugar in Java. Indonesian Sugar Experiment Station, Pasuruan, Indonesia. Vol. 7, final instalment. Atlas of 220 weeds of sugarcane fields in Java. Fig. 737. Redrawn and adapted by Iskak Syamsudin.

Cosmos caudatus: Backer, C.A., 1973 (edited by van Steenis, C.G.G.J.). Weed flora of Javanese sugar-cane fields. Handbook for the cultivation of sugar-cane and manufacturing of cane-sugar in Java. Indonesian Sugar Experiment Station, Pasuruan, Indonesia. Vol. 7, final instalment. Atlas of 220 weeds of sugarcane fields in Java. Fig. 737. Redrawn and adapted by Iskak Syamsudin.

Cucumis melo: Museum of Natural History, University of the Philippines at Los Baños, College, Laguna, the Philippines. Original drawing by R.D. Tandang. Redrawn and adapted by P. Verheij-Hayes.

Cucumis sativus: Hegi, G., 1979. Illustrierte Flora von Mitteleuropa. 2nd edition. Verlag Paul Parey, Berlin, Germany. Vol. 6(2). p. A23, Fig. A9. Redrawn and adapted by P. Verheij-Hayes.

Cucurbita ficifolia: Brown, W.H., 1951–1957. Useful plants of the Philippines. Reprint of the 1941–1943 edition. Department of Agriculture and Natural Resources. Technical Bulletin 10. Bureau of Printing, Manila, the Philippines. Vol. 3. p. 384, Fig. 156. Redrawn and adapted by Iskak Syamsudin.

Cucurbita moschata: Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 195 & 198, Figs. 118 & 120. Redrawn and adapted by P. Verheij-Hayes.

Daucus carota: Langer, R.H.M. & Hill, G.D., 1982. Agricultural plants. Cambridge University Press, United Kingdom. p. 287, Fig. 15.1 (habit); Heukels, H. & van Ooststroom, S.J., 1977. Flora van Nederland. 19th edition. Wolters-Noordhoff, Groningen, the Netherlands. p. 453, Fig. 497 (flowering and fruiting shoot, fruit, seed). Redrawn and adapted by Iskak Syamsudin.

Emilia sonchifolia: Li, Hui-Lin, 1978. Compositae. In: Li, Hui-Lin et al. (Editors): Flora of Taiwan. Epoch Publishing Company, Taipei, Taiwan. Vol. 4. p. 854, Fig. 1224. Redrawn and adapted by Iskak Syamsudin.

Enydra fluctuans: Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G., 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 83, Fig. 4.27. Redrawn and adapted by Achmad Satiri Nurhaman.

Erechtites hieracifolia: Original drawing by P. Verheij-Hayes after M.H. Aarts-van den Bergh, s.n., November 1989, WAG.

Hibiscus acetosella: Stevels, J.M.C., 1990. Légumes traditionnels du Cameroun, une étude agro-botanique. Wageningen Agricultural University Papers 90-1. p. 175, Fig. 5.28. Redrawn and adapted by Iskak Syamsudin.

Hibiscus sabdariffa: Matthew, K.M., 1988. Further illustrations on the flora of the Tamilnadu Carnatic. The Rapinat Herbarium, Tiruchirapalli, India. p. 40, Fig. 40. Redrawn and adapted by Achmad Satiri Nurhaman.

Hydrocotyle sibthorpioides: Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G., 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 51, Fig. 4.12. Redrawn and adapted by Achmad Satiri Nurhaman.

Ipomoea aquatica: Westphal, E. & Jansen, P.C.M. (Editors), 1989. Plant Resources of South-East Asia. A selection. Pudoc, Wageningen. p. 164.

Lactuca indica: Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. p. 136, Fig. 83. Redrawn and adapted by P. Verheij-Hayes.

Lactuca sativa: Voskuil, J., 1983. Zaai en plantgids voor de moestuin. Thieme, the Netherlands. p. 82 (butterhead lettuce, crisp lettuce, bunching lettuce, stem lettuce); Buishand, T., Houwing, H.P. & Jansen, K., 1986. Groenten uit alle windstreken. Spectrum, Utrecht, the Netherlands. p. 56 (cos lettuce). Redrawn and adapted by Iskak Syamsudin & P. Verheij-Hayes.

Lagenaria siceraria: Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. pp. 324 & 325, Figs. 88 & 89. Redrawn and adapted by Iskak Syamsudin.

Limnocharis flava: Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G., 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 119, Fig. 4.45. Redrawn and adapted by Achmad Satiri Nurhaman.

Luffa acutangula: Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. p. 327, Fig. 90 (flowering shoot, female flower); Sastrapradja, S. et al., 1981. Vegetables (translation of 'Sayur-sayuran', 1977). IBPGR, Rome, Italy. p. 56 (fruit). Redrawn and adapted by Iskak Syamsudin.

Lycium chinense: Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. p. 174, Fig. 24 (leafy shoot); Liu, Yeh-Ching, 1978. Solanaceae. In: Li, Hui-Lin et al. (Editors): Flora of Taiwan. Epoch Publishing Company, Taipei, Taiwan. Vol. 4. p. 534, Fig. 1094 (flowering and fruiting shoot). Redrawn and adapted by Iskak Syamsudin.

Lycopersicon esculentum: Hegi, G., 1927. Illustrierte Flora von Mitteleuropa. 1st edition. Lehmanns Verlag, München, Germany. Vol. 5(4). p. 2607, Fig. 3424. Redrawn and adapted by P. Verheij-Hayes.

Melientha suavis: Pierre, L., 1892. Flore forestière de la Cochinchine. Fasc. 17. Paris, France. Fig. 264. Redrawn and adapted by Iskak Syamsudin.

Momordica charantia: Purseglove, J.W., 1972. Tropical crops. Monocotyledons. Longman, London, United Kingdom. Vol. 1. p. 133, Fig. 21. Redrawn and adapted by Iskak Syamsudin.

Monochoria vaginalis: Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G., 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 489, Fig. 4.228. Redrawn and adapted by Achmad Satiri Nurhaman.

Moringa oleifera: Stevels, J.M.C., 1990. Légumes traditionnels du Cameroun, une étude agrobotanique. Wageningen Agricultural University Papers 90-1. p. 87, Fig. 5.11. Redrawn and adapted by Soejitno.

Musa salaccensis: Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. p. 519, Fig. 320. Redrawn and adapted by Iskak Syamsudin.

Neptunia oleracea: Matthew, K.M., 1982. Illustrations on the flora of the Tamilnadu Carnatic. The Rapinat Herbarium, Tiruchirapalli, India. p. 247, Fig. 247. Redrawn and adapted by Iskak Syamsudin.

Ocimum americanum: Backer, C.A., 1973 (edited by van Steenis, C.G.G.J.). Weed flora of Javanese sugar-cane fields. Handbook for the cultivation of sugar-cane and manufacturing of cane-sugar in Java. Indonesian Sugar Experiment Station, Pasuruan, Indonesia. Vol. 7, final instalment. Atlas of 220 weeds of sugar-cane fields in Java. Fig. 544. Redrawn and adapted by Jitno Rijadi.

Oenanthe javanica: Liu, Tang-Shui, 1977. Umbelliferae. In: Li, Hui-Lin et al. (Editors): Flora of Taiwan. Epoch Publishing Company, Taipei, Taiwan. Vol. 3. p. 958, Fig. 884. Redrawn and adapted by Iskak Syamsudin.

Parkia speciosa: Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. p. 405, Fig. 251 (flowering and fruiting shoot); Smitinand, T. & Larsen, K. (Editors), 1985. Flora of Thailand. The Forest Herbarium, Royal Forest Department, Bangkok, Thailand. Vol. 4(2). p. 226, Fig.

8(1) (inflorescence). Redrawn and adapted by Jitno Rijadi & P. Verheij-Hayes.

Pilea trinervia: Liu, Tang-Shui, 1976. Urticaceae. In: Li, Hui-Lin et al. (Editors): Flora of Taiwan. Epoch Publishing Company, Taipei, Taiwan. Vol. 2. p. 217, Fig. 271. Redrawn and adapted by Iskak Syamsudin.

Polyscias verticillata: Henderson, C.P. & Hancock, I.R., 1988. A guide to the useful plants of Solomon Islands. Ministry of Agriculture and Lands, Honiara, Solomon Islands. p. 113, Fig. 42. Redrawn and adapted by Achmad Satiri Nurhaman.

Portulaca oleracea: Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G., 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 491, Fig. 4.229. Redrawn and adapted by Achmad Satiri Nurhaman.

Psophocarpus tetragonolobus: Westphal, E. & Jansen, P.C.M. (Editors), 1989. Plant Resources of South-East Asia. A selection. Pudoc, Wageningen. p. 233.

Raphanus sativus: Nicholson, B.E., Harrison, S.G., Masefield, G.B. & Wallis, M., 1969. The Oxford book of food plants. Oxford University Press, United Kingdom. p. 171, Fig. 2. Redrawn and adapted by P. Verheij-Hayes.

Rheum cultorum: Nicholson, B.E., Harrison, S.G., Masefield, G.B. & Wallis, M., 1969. The Oxford book of food plants. Oxford University Press, United Kingdom. p. 163, Fig. 1. (habit, petiole); Mansfeld, R., 1986. Verzeichnis landwirtschaftlicher und gärtnerischer Kulturpflanzen (ohne Zierpflanzen). 2nd edition. Springer Verlag, Berlin, Germany. Vol. 1. p. 111, Fig. 18 (inflorescence branch, flower, fruit). Redrawn and adapted by P. Verheij-Hayes.

Rorippa nasturtium-aquaticum: Wagenvoort, H. & de Geus, M., 1983. Grenzeloze groenten. KIM Natuurboeken, Baarn, the Netherlands. p. 28. Redrawn and adapted by Iskak Syamsudin.

Rungia klossii: original drawing by W. Wessel-Brand, based on Vink 16324 (L).

Saccharum edule: Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. p. 338, Fig. 214. Redrawn and adapted by Iskak Syamsudin.

Sauropus androgynus: Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische Groenten', 1931). Asher & Co., Amsterdam, the Netherlands. p. 291, Fig. 186 (flowering and fruiting shoot); Pax, F. & Hoffmann, K., 1931. Euphorbiaceae. In: Engler, A. & Prantl, K. (Editors): Die natürlichen Pflanzenfamilien. 2nd edition. Vol. 19C. Wilhelm Engelmann Verlag, Leipzig, Germany. p. 71, Fig. 34 (female flower, male flower). Redrawn and adapted by P. Verheij-Hayes.

Sechium edule: de Martius, C.F.P., 1878–1885. Flora Brasiliensis. Vol. 6(4). Fig. 35 (flowering and fruiting shoot, male flower, female flower, fruit with germinating seed); Hegi, 1918. Illustrierte Flora von Mitteleuropa. 1st edition. Lehmanns Verlag, München, Germany. Vol. 6(1). p. 313, Fig. 168 (fruits). Redrawn and adapted by P. Verheij-Hayes.

Solanum americanum: Backer, C.A. & van Slooten, D.F., 1924. Geïllustreerd handboek der Javaansche theeonkruiden en hunne betekenis voor de cultuur. Ruygrok, Batavia, Dutch East Indies. Fig. 195. Redrawn and adapted by Jitno Rijadi.

Solanum ferox: Hepper, F.N., 1987. Solanaceae. In: Dassanayake, M.D. & Fosberg, F.R. (Editors): A revised handbook to the flora of Ceylon. Amerind Publishing Company, New Delhi, India. Vol. 6. p. 372, Fig. 1. Redrawn and adapted by P. Verheij-Hayes.

Solanum melongena: Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. p. 382, Fig. 111. Redrawn and adapted by Jitno Rijadi.

Solanum torvum: Backer, C.A. & van Slooten, D.F., 1924. Geïllustreerd handboek der Javaansche theeonkruiden en hunne betekenis voor de cultuur. Ruygrok, Batavia, Dutch East Indies. Fig. 196. Redrawn and adapted by Achmad Satiri Nurhaman.

Sonchus oleraceus: Li, Hui-Lin. 1978. Compositae. In: Li, Hui-Lin et al. (Editors): Flora of Taiwan. Epoch Publishing Company, Taipei, Taiwan. Vol. 4. p. 941, Fig. 1254. Redrawn and adapted by Jitno Rijadi.

Sonneratia caseolaris: Koorders, S.H. & Valeton, Th., 1915. Atlas der Baumarten von Java. Vol. 3(12). Trap, Leiden, the Netherlands. Figs. 593 & 594 (habit of tree, shoot with flower bud); Tomlinson, P.B., 1986. The botany of mangroves. Cambridge University Press, Cambridge, United Kingdom. p. 369, Fig. B79 (flower, fruit). Redrawn and adapted by P. Verheij-Hayes.

Spilanthes paniculata: Backer, C.A., 1973 (edited by van Steenis, C.G.G.J.). Weed flora of Javanese sugar-cane fields. Handbook for the cultivation of sugar-cane and manufacturing of cane-sugar in Java. Indonesian Sugar Experiment Station, Pasuruan, Indonesia. Vol. 7, final instalment. Atlas of 220 weeds of sugar-cane fields in Java. Fig. 731. Redrawn and adapted by Jitno Rijadi.

Spinacia oleracea: Herklots, G.A.C., 1972. Vegetables in South-East Asia. George Allen & Unwin, London, United Kingdom. p. 159, Fig. 15 (habit); van der Vossen, H.A.M. Private collection (shoot with female inflorescences, shoot with male inflorescences, round seed, prickly seed). Redrawn and adapted by Jitno Rijadi.

Talinum triangulare: Stevels, J.M.C., 1990. Légumes traditionnels du Cameroun, une étude agro-botanique. Wageningen Agricultural University Papers 90-1. p. 93, Fig. 5.13. Redrawn and adapted by P. Verheij-Hayes.

Tetragonia tetragonioides: Liu, Tang-Shui & Chen, Ming-Che, 1976. Aizoaceae. In: Li, Hui-Lin et al. (Editors): Flora of Taiwan. Epoch Publishing Company, Taipei, Taiwan. Vol. 2. p. 312, Fig. 308 (flowering and fruiting shoot, fruit); Wagenvoort, H. & de Geus, M., 1983. Grenzeloze groenten. KIM Natuurboeken, Baarn, the Netherlands. p. 18 (flower). Redrawn and adapted by P. Verheij-Hayes.

Trichosanthes cucumerina: Purseglove, J.W., 1968. Tropical crops. Dicotyledons. Longman, London, United Kingdom. Vol. 1. p. 137, Fig. 23. Redrawn and adapted by P. Verheij-Hayes.

Vigna unguiculata cv. group Sesquipedalis: Purseglove, J.W., 1968. Tropical crops. Dicotyledons. Longman, London, United Kingdom. Vol. 1. p. 323, Fig. 50 (fruiting shoot); van der Maesen, L.J.G. & Sadikin Somaatmadja (Editors), 1989. Plant resources of South-East Asia 1. Pulses. Pudoc/Prosea, Wageningen, the Netherlands. p. 78 (inflorescence). Redrawn and adapted by P. Verheij-Hayes.

Zizania latifolia: Siemonsma, J.S. & van den Bergh, M.H., 1990. Collection of photographs. Drawn and adapted by P. Verheij-Hayes.

Map of South-East Asia for Prosea: original design of R. Boekelman.

Index of scientific plant names

Page numbers printed in bold refer to main treatment.

Index of vernacular plant names

Page numbers printed in bold refer to main treatment. For transcriptions of Vietnamese names, see at the end of the index.

Transcriptions of Vietnamese names:

[aa] = â
[aaf] = ầ
[aaj] = ậ
[aar] = ẩ
[aas] = ấ
[aax] = ẫ
[af] = à
[aj] = ạ
[ar] = ả
[as] = á
[aw] = ă
[awf] = ằ
[awj] = ặ
[awr] = ẳ
[aws] = ắ
[awx] = ẵ
[ax] = ã
[ee] = ê
[eef] = ề
[eej] = ệ
[eer] = ể
[ees] = ế
[eex] = ễ
[ef] = è
[ej] = ẹ
[er] = ẻ
[es] = é
[ex] = ẽ
[if] = ì
[is] = í
[of] = ò
[oj] = ọ
[oo] = ô
[oof] = ồ
[ooj] = ộ
[oor] = ổ
[oos] = ố
[oox] = ỗ
[or] = ỏ
[os] = ó
[ow] = ơ
[owf] = ờ
[owj] = ợ
[owr] = ở
[ows] = ớ
[owx] = ỡ
[ox] = õ
[uf] = ù
[uj] = ụ
[ur] = ủ
[us] = ú
[uw] = ư
[uwf] = ừ
[uwj] = ự
[uwr] = ử
[uws] = ứ
[uwx] = ữ
[ux] = ũ

The Prosea Foundation
(Plant Resources of South-East Asia)

Name, location, legal status and structure

- Prosea is a Foundation under Indonesian law, with an international charter, domiciled in Bogor. It is an autonomous, non-profit, international agency, governed by a Board of Trustees. It seeks linkage with existing regional and international organizations;
- Prosea is an international programme focusing on the documentation of information on plant resources of South-East Asia;
- Prosea consists of a Network Office at Bogor (Indonesia) coordinating 6 Country Offices in South-East Asia, and a Publication Office in Wageningen (the Netherlands).

Participating institutions

- Forest Research Institute of Malaysia (FRIM), Karung Berkunci 201, Jalan FRI Kepong, 52109 Kuala Lumpur, Malaysia;
- Indonesian Institute of Sciences (LIPI), Widya Graha, Jalan Gatot Subroto 10, Jakarta 12710, Indonesia;
- Institute of Ecology & Biological Resources (NCSR), Nghia do, Tu Liem, Hanoi, Vietnam;
- Papua New Guinea University of Technology (UNITECH), Private Mail Bag, Lae, Papua New Guinea;
- Philippine Council for Agriculture, Forestry and Natural Resources Research & Development (PCARRD), Los Baños, Laguna, the Philippines;
- Thailand Institute of Scientific and Technological Research (TISTR), 196 Phahonyothin Road, Bang Khen, Bangkok 10900, Thailand;
- Wageningen Agricultural University (WAU), Costerweg 50, 6701 BH Wageningen, the Netherlands.

Objectives

- to document and make available the existing wealth of information on the plant resources of South-East Asia for education, extension work, research and industry;
- to make operational a computerized data bank on the plant resources of South-East Asia;
- to publish the results in the form of an illustrated, multi-volume handbook in English;
- to promote the dissemination of the information gathered.

Target groups

- those professionally concerned with plant resources in South-East Asia and working in education, extension work, research and commercial production (direct users);
- those in South-East Asia depending directly on plant resources, obtaining relevant information through extension (indirect users).

Activities

- the establishment and operation of data bases;
- the publication of books;
- the sponsorship, support and organization of training courses;
- research into topics relevant to Prosea's purpose;
- the publication and disseminaton of reports and the research results.

Implementation

The programme period has been tentatively divided into 3 phases:
- preliminary phase (1985–1986): publication of 'Plant Resources of South-East Asia, Proposal for a Handbook' (1986);
- preparatory phase (1987–1990): establishing cooperation with South-East Asia through internationalization, documentation, consultation and publication; reaching agreement on the scientific, organizational and financial structure of Prosea;
- implementation phase (1991–1995): compilating, editing and publishing of the handbook; making operational the computerized data bank with the texts and additional information; promoting the dissemination of the information obtained.

Documentation

A documentation system has been developed for information storage and retrieval called SAPRIS (South-East Asian Plant Resources Information System). It consists of 6 data bases:
- BASELIST: primarily a checklist of more than 6200 plant species;
- CATALOG: references to secondary literature;
- PREPHASE: references to literature from South-East Asia;
- ORGANYM: references to institutions and their research activities;
- PERSONYM: references to specialists;
- TEXTFILE: all Prosea publications and additional information.

Publication

The handbook in blue cover (hardbound) is distributed by Pudoc, the low-price edition in green cover (paperback) by Prosea only in developing countries of South-East Asia and the Pacific, the bibliographies by Prosea and the miscellaneous publications by Pudoc and Prosea.

The handbook

- No 1. Pulses.L.J.G. van der Maesen and Sadikin Somaatmadja (Editors). Pudoc, Wageningen. 1989/ESCAP CGPRT Centre, Bogor. 1990 (out of print)/Prosea, Bogor. 1992.
- No 2. Edible fruits and nuts. E.W.M. Verheij and R.E. Coronel (Editors). Pudoc, Wageningen. 1991/Prosea, Bogor. 1992.
- No 3. Dye and tannin-producing plants. R.H.M.J. Lemmens and N. Wulijarni-Soetjipto (Editors). Pudoc, Wageningen. 1991/Prosea, Bogor. 1992.
- No 4. Forages. L. 't Mannetje and R.M. Jones (Editors). Pudoc, Wageningen. 1992/Prosea, Bogor. 1992.
- No 5(1). Timber trees. Major commercial timbers. I. Soerianegara and R.H.M.J. Lemmens (Editors). Pudoc, Wageningen. 1993/Prosea, Bogor. 1994.
- No 5(2). Timber trees. Minor commerical timbers. R.H.M.J. Lemmens, I. Soerianegara and Wong Wing Chong (Editors). (expected publication date 1994/1995).
- No 6. Rattans. J. Dransfield and N. Manokaran (Editors). Pudoc, Wageningen. 1993/Prosea, Bogor. 1994.
- No 7. Bamboos. S. Dransfield and E.A. Widjaja (Editors). (expected publication date 1994).
- No 8. Vegetables. J.S. Siemonsma and Kasem Piluek (Editors). Pudoc, Wageningen. 1993/Prosea, Bogor. 1994.
- No 9. Plants mainly producing carbohydrates. F. Rumawas and M. Flach (Editors). (expected publication date 1994).
- No 10. Cereals.
- No 11. Auxiliary plants in agriculture and forestry. F.H. Ibrahim and L.J.G. van der Maesen (Editors). (expected publication date 1994).

Bibliographies

- Bibliography 1: Pulses. Edition 1. N. Wulijarni-Soetjipto and J.S. Siemonsma (Editors). Prosea, Bogor. 1990.
- Bibliography 2: Edible fruits and nuts. Edition 1. N. Wulijarni-Soetjipto and J.S. Siemonsma (Editors). Prosea, Bogor/Pudoc, Wageningen. 1993.
- Bibliography 3: Dye and tannin-producing plants. Edition 1. N. Wulijarni-Soetjipto and J.S. Siemonsma (Editors). Prosea, Bogor/Pudoc, Wageningen. 1991.

Miscellaneous

- A Selection. E. Westphal and P.C.M. Jansen (Editors). Pudoc, Wageningen. 1989/Prosea, Bogor. 1993.
- Basic list of species and commodity grouping. Version 1. R.H.M.J. Lemmens, P.C.M. Jansen, J.S. Siemonsma, F.M. Stavast (Editors). Prosea Project, Wageningen. 1989. (out of print).
- Basic list of species and commodity grouping. Final version. P.C.M. Jansen, R.H.M.J. Lemmens, L.P.A. Oyen, J.S. Siemonsma, F.M. Stavast and J.L.C.H. van Valkenburg (Editors). Pudoc, Wageningen. 1991/Prosea, Bogor. 1993.
- Proceedings of the First Prosea International Symposium, May 22–25, 1989. Jakarta, Indonesia. J.S. Siemonsma and N. Wulijarni-Soetjipto (Editors). Pudoc, Wageningen. 1989. (out of print).

In brief, Prosea is

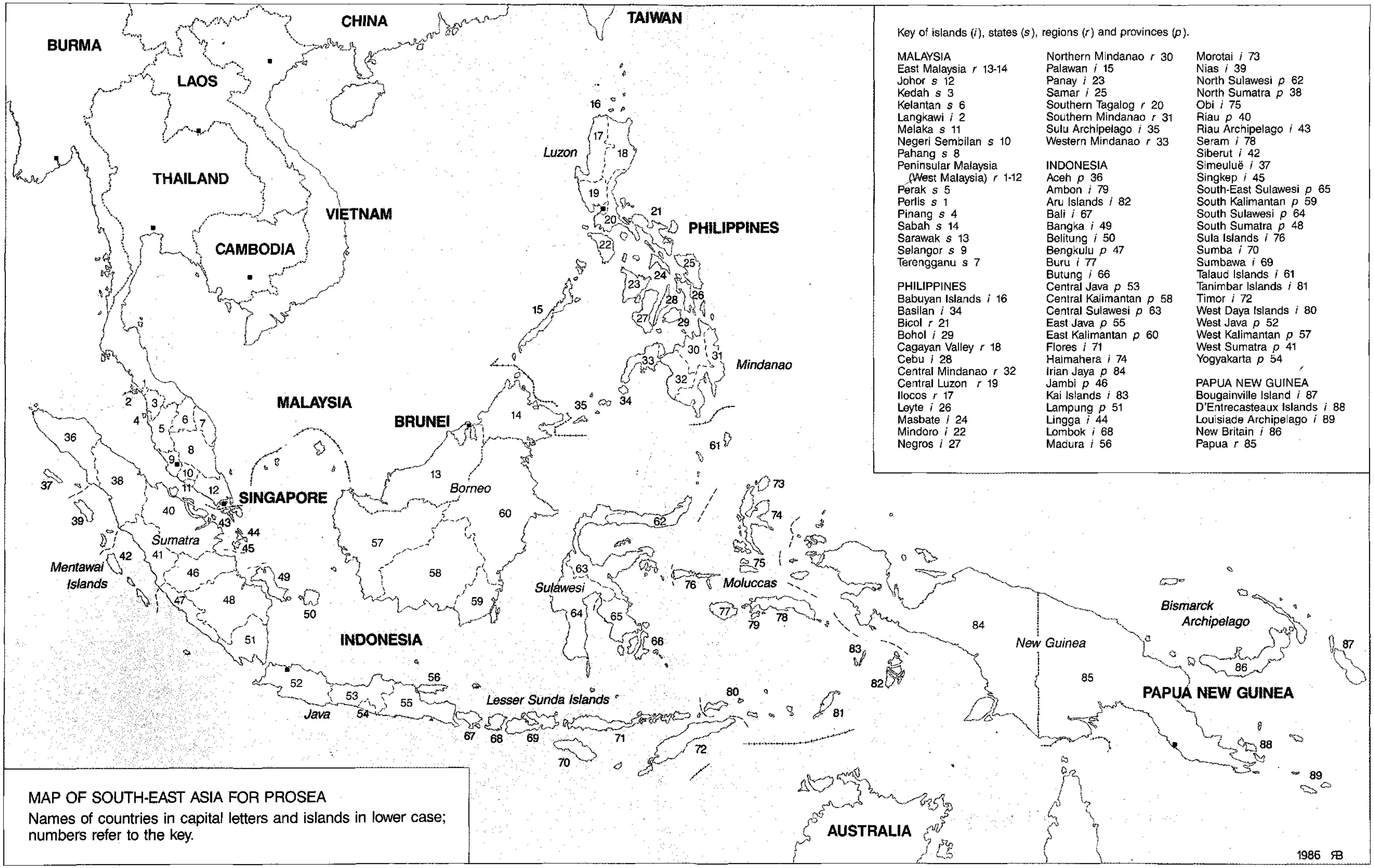
- an international programme, focused on plant resources of South-East Asia;
- interdisciplinary, covering the fields of agriculture, forestry, horticulture and botany;
- a research programme, making knowledge available for education and extension;
- ecologically focused on promoting plant resources for sustainable tropical land-use systems;
- committed to conservation of biodiversity;
- committed to rural development through diversification of resources and application of farmers' knowledge.

Prosea Network Office

Centre for Research & Development in Biology
Jalan Raya Juanda 22–24
P.O. Box 234
Bogor 16122, Indonesia
tel: (0251) 322 859
telex: c/o 48304 BPPHBG
fax: (62) (251) 322 859

Prosea Publication Office

Wageningen Agricultural University
P.O. Box 341
6700 AH Wageningen, the Netherlands
tel: (08370) 84587
telex: 45917 BURLU
fax: (31) (8370) 82206



MAP OF SOUTH-EAST ASIA FOR PROSEA
Names of countries in capital letters and islands in lower case; numbers refer to the key.