Pulses in Ethiopia, their taxonomy and agricultural significance

E. Westphal

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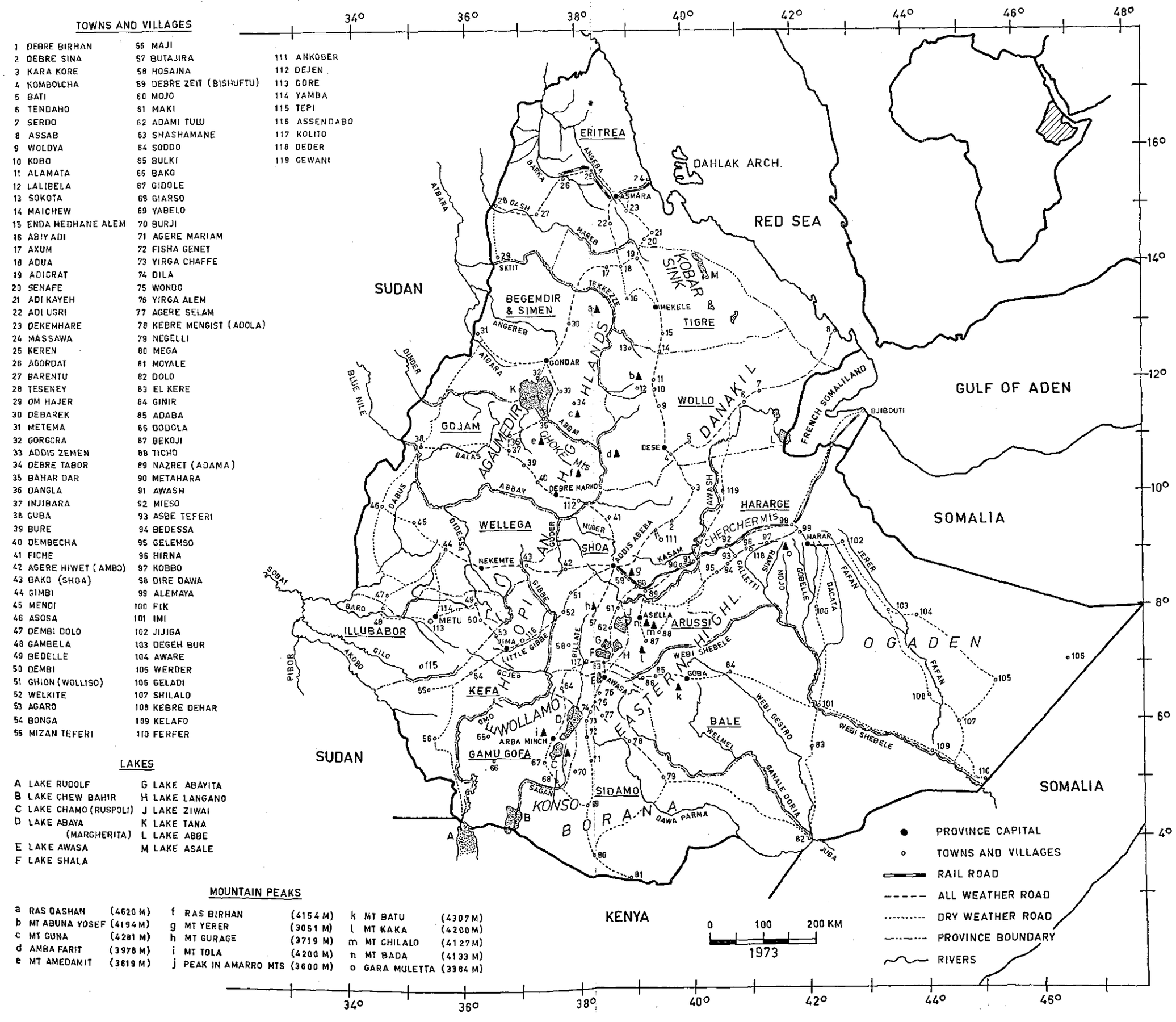
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k MT BATU (4307 M)
l MT KAKA (4200 M)
m MT CHILALO (4127 M)
n MT BADA (4133 M)
o GARA MULETTA (3384 M)
34° 36° 38° 40° 42° 44° 46° 48°
16° 14° 12° 10° 8° 6° 4°
ERITREA
DAHLAK ARCH.
RED SEA
GULF OF ADEN
SUDAN
SOMALIA
KENYA
FRENCH SOMALILAND
DJIBOUTI
ASMARA
BARKA
ANSEBA
ATBARA
SETIT
GASH
MAREB
KOBAR SINK
BEGEMDIR & SIMEN
ANGEREB
TEKKEZZE
MEKELE
TIGRE
GONDAR
DINDER
BLUE NILE
GOJAM
AGAUMEDIR HIGHLANDS
CHOKE MTS
ABBAY
BALAS
DESE
WOLLO
DANAKIL
DEBRE MARKOS
DABUS
DIDESSA
WELLEGA
MUGER
AWASH
HARARGE
CHERCHERMTS
HARAR
JERER
FAFAN
WELLEGA
NEKEMTE
GIBBE
GODER
SHOA
ADDIS ABEBA
KASAM
GALLETTI
RAMIS
OGDEN
DACATA
SOBAT
BARO
ILLUBABOR
PIBOR
AKOBO
GILO
GOJEB
LITTLE GIBBE
METU
JIMA
ETHIOPIAN HIGHLANDS
ARUSSI
ASELLA
IPSILATE
WEBI SHEBELE
GOBA
AWASA
KEFA
WOLLAMO
OMO
ARBA MINCH
GAMU GOFA
SAGAN
SIDAMO
KONSO
BORANA
EASTERN HIGHLANDS
BALE
WELMEL
GANALE DORIA
WEBI GESTRO
DAWA PARMA
JUBA
PROVINCE CAPITAL
TOWNS AND VILLAGES
RAIL ROAD
ALL WEATHER ROAD
DRY WEATHER ROAD
PROVINCE BOUNDARY
RIVERS
0 100 200 KM
1973

Abstract

WESTPHAL, E. (1974) Pulses in Ethiopia, their taxonomy and agricultural significance. Doctoral thesis, Wageningen, ISBN 90 220 0501 1, (viii) + 276 p., 28 figs, 72 plates, 1 table, 204 refs, Dutch summary, indexes of common and scientific plant names.
Also: Agric. Res. Rep. (Versl. landbouwk. Onderz.) 815.

The book is the first in a series of publications on Ethiopian useful plants. It treats 19 papilionaceous crops, both from a taxonomic and an agricultural standpoint.

Special chapters are dedicated to the physical and biological environment, the agro-ecological regions in which the country can be divided, the agricultural systems, and some taxonomic problems with special reference to 'cultivar' taxonomy.

The extensive botanical description of each taxon is accompanied by a full-page drawing, photographs of the seeds, lists of synonyms, literature and names, and details on taxonomic problems, occurrence, ecology, husbandry, uses and protein content.

Indices on common and scientific plant names are added.

Cover plate by H. C. D. de Wit.

ISBN 90 220 0501 I

This thesis will also be published as Agricultural Research Reports 815.

Stellingen

I

De historisch verklaarbare 'incompatibilité des humeurs' tussen plantenveredelaars en plantensystematici vormt een belemmering voor nauwe samenwerking tussen beider vakgebieden ter betere ontplooiing van de systematiek van cultuurgewassen.

J. G. Hawkes, in: O. H. Frankel & E. Bennett, eds, 1970. Genetic resources in plants—their exploration and conservation: 69-85. Oxford.

II

De resultaten van experimenteel onderzoek steunen in het algemeen de conclusies van systematisch onderzoek op en boven het niveau van de soort gebaseerd op representatieve herbariumcollecties en veldwaarnemingen; omgekeerd geven deze conclusies richting aan, en bepalen mede de probleemstelling van het experimenteren.

III

Kenmerkend voor de ensat-hak landbouw in vergelijking met de zaad-ploeg landbouw in Ethiopië zijn de grotere oogstzekerheid die de verbouw van ensat biedt, en het relatief hoge niveau van bodemvruchtbaarheid door gebruik van dierlijke mest.

H. Smeds, 1955. Acta geogr. Helsingf. 13(4): 1-39.
S. Stanley, 1966. Ethiopian Geogr. J. 4(1): 30-37.

IV

Het voorstel van Verdcourt tot retypificatie van het genus *Dolichos* L. (1754; type *D. lablab* L.) met *D. trilobus* L. pro parte dient, als strijdig met de Code, verworpen te worden.

Report Committee for Spermatophyta, 1972. Taxon 21(4): 533-534.
E. Westphal, 1974. Taxon 23(2) (in voorbereiding).

V

In de morfologie en systematiek goed omschreven termen dienen ook in publikaties op het gebied van de genetica en plantenveredeling met zorgvuldigheid, dus volgens hun eigenlijke inhoud, te worden gebruikt.

R. Prakken, 1970. Meded. LandbHogesch. Wageningen 70(23): 19.
J. R. Harlan & J. M. J. de Wet, 1971. Taxon 20(4): 509-517.

VI

De constatering van Kousbroek, dat gecultiveerde mensen tegenover de cultuur staan met de instelling van een lekkerbek en niet met die van een theoloog, doet twijfel rijzen aan de kwaliteit van Kousbroek als lekkerbek.

R. Kousbroek, 1973. NRC Handelsblad 22 juni: Cult. Suppl.

VII

De tekortkomingen in veel tekeningen in het standaardwerk 'Tropical Crops' van Purseglove benadelen de correcte weergave van habitus en kenmerkende onderdelen van een plant, die voor onderwijs en gebruik in de praktijk noodzakelijk is.

J. W. Purseglove, 1968, 1972. Tropical Crops. 4 vols. London.

VIII

De bescheiden rol die de plantensystematiek en -geografie is toebedeeld aan de Landbouwhogeschool stemt overeen met de opvatting van De Wit, die het succes van de romanheld Prikkebeen toeschrijft aan het idee dat deze figuur de systematicus goed typeert.

H. C. D. de Wit, 1957. Inaugurele rede: 5.

IX

De huidige houding van de Wereldraad van Kerken ten opzichte van het racisme getuigt van weinig affiniteit tot economische en oecumenische vraagstukken.

X

Binnen de studierichting Tropische Plantenteelt is meer nadruk op basisvakken en toespitsing op concrete, voor de tropische plantenteelt relevante probleemstellingen gewenst, naast de ontwikkeling van een, voor de tropen onontbeerlijke, praktische instelling.

XI

Het gegeven dat in Nederland jaarlijks miljoenen kilo's brood op de vuilnisbelt belanden is meer het gevolg van de kwaliteit van het Nederlandse brood dan van onbekendheid met het wereldvoedselvraagstuk.

XII

Het getuigt van weinig realiteitszin om bij eventuele hervormingen in de Ethiopische samenleving de beslissende invloed te veronachtzamen, die de Koptische kerk door de eeuwen heen heeft uitgeoefend op de ontwikkelingen binnen het Ethiopische rijk.

R. Greenfield, 1965. Ethiopia, a new political history. New York.

XIII

Kwalificaties als progressief en conservatief hangen, in tegenstelling tot links- en rechtswindendheid bij *Dioscorea's*, af van de plaats van de waarnemer ten opzichte van het waar te nemen subject.

XIV

Een goed voorbeeld van illustratief taalgebruik is, dat heden ten dage het woord 'geleerde' in onbruik raakt en door de aanduiding 'wetenschapper' vervangen dreigt te worden.

Proefschrift van E. Westphal
Wageningen, 15 maart 1974

Curriculum vitae

Egbert Westphal, geboren 24 augustus 1938 te Semarang (Indonesië)
Studie Landbouwhogeschool, richting Tropische Landbouwplantenteelt, 1957–1966
Ingenieursdiploma: tropische landbouwplantenteelt, plantenveredeling, fytopathologie en erfelijkheidsleer
1966–1969: werkzaam in bilateraal ontwikkelingsproject ter inventarisatie van Ethiopische voedingsgewassen; gedurende 1967–1968 in Ethiopië
1969–1974: wetenschappelijk medewerker der Landbouwhogeschool, afdeling Tropische Plantenteelt

Samenvatting

Deze studie is een systematisch-botanische en landbouwkundige bewerking van 19 in Ethiopië voorkomende vlinderbloemige voedingsgewassen.

Het voorwoord en de inleiding geven bijzonderheden over het project van Ethiopische gewassen en nuttige planten; over de methoden en het gebruikte materiaal, de collecties, de beschrijvingen, tekeningen, foto's; over het somatische chromosoomgetal, het eiwitgehalte, de fotoperiodiciteit; over Ethiopische woorden en hun uitspraak; over de termen variëteit, cultivar (cv.), cultivar-groep (cv.-groep), tropen en subtropen, en over de plaats van hoofdstuk 4 in het kader van deze studie.

Hoofdstuk 2 geeft een overzicht van het fysische en biologische milieu van Ethiopië. Als belangrijk gegeven komt de invloed naar voren van de hoogte boven zeeniveau op klimaat, bodem, natuurlijke vegetatie en ethnische groepen.

Hoofdstuk 3 vermeldt de belangrijkste agro-ecologische gebieden. Vervolgens worden de verschillen tussen ensat-hak landbouw en zaad-ploeg landbouw uiteengezet. Tenslotte volgt de behandeling van de volgende landbouw typen: (1) het zaad-ploeg type van het Ethiopische Hoogland; (2) het gerst-hak type van de Galla; (3) het zaad-ploeg type van Arussi en Bale; (4) het sorghum-ploeg type van het hoogland van Hararge; (5) het sorghum-hak-terrassen type van de Konso-groep; (6) het type met ensat als enig stapelvoedsel; (7) het type met ensat, granen en knolgewassen als stapelvoedsel; (8) het type met knolgewassen als stapelvoedsel, met granen op de tweede plaats, waarbij ensat geen stapelvoedsel is; (9) het type met granen als stapelvoedsel, met knolgewassen op de tweede plaats, waarbij ensat geen stapelvoedsel is; (10) zwerfbouw; en (11) veeteelt.

Hoofdstuk 4 schetst eerst de reikwijdte van de plantensystematiek in het algemeen, gevolgd door een uiteenzetting van het belang van deze wetenschap voor cultuurgewassen ('cultivar-systematiek').

Hoofdstuk 5 begint met een overzicht van in Ethiopië voorkomende vlinderbloemigen, wild of in cultuur, die voor voeding worden gebruikt. Hierop volgen twee determinatie-tabellen: de eerste gebaseerd op algemene kenmerken, de tweede op zaadkenmerken. Tenslotte volgt de bewerking van 19 peulvruchten, in alfabetische volgorde: *Cajanus cajan*, *Canavalia ensiformis*, *C. virosa*, *Cicer arietinum*, *Dolichos lablab*, *Lathyrus sativus*, *Lens culinaris*, *Lupinus albus* cv.-groep Albus, *Mucuna pruriens* cv.-groep Utilis, *Phaseolus coccineus*, *P. lunatus*, *P. radiatus*, *P. vulgaris*, *Pisum sativum* cv.-groep Abyssinicum, *P. sativum* cv.-groep Sativum, *Psophocarpus palustris*, *Trigonella foenum-graecum*, *Vicia faba* en *Vigna unguiculata*, waarbij een apart onderdeel is gewijd aan het geslacht *Phaseolus* L.

Na verwijzing naar het somatisch chromosoomgetal, voor zover bepaald aan Ethiopisch materiaal, en tekeningen en foto's, volgen voor elk gewas de etymologie van de wetenschappelijke naam, de typificatie, een overzicht van de synonymie van het betreffende taxon alsmede een overzicht van de belangrijkste taxonomische, landbouwkundige en andere literatuur; lokale namen, handelsnamen, geografische verspreiding; een botanische beschrijving van het gewas (blad, bloem, vrucht, zaad, kiemplant) gebaseerd op uit Ethiopië afkomstig materiaal met botanische tekeningen en foto's van het zaad; taxonomische opmerkingen betreffende typificatie en andere relevante taxonomische problemen; naamgeving van cultivars, vermelding van verschillen tussen in Ethiopië en Wageningen verbouwde planten, een lijst van verzamelnummers; een ecologische karakteristiek; verbouwmethoden, gebruik, met ten slotte gegevens betreffende het eiwitgehalte.

Het geheel wordt afgesloten met een Index van plantenamen en een Index van wetenschappelijke plantenamen.

Contents

Preface

During the period April 1967-August 1968 the author was attached to the College of Agriculture at Alemaya of the Haile Sellassie I University of Ethiopia to work on a bilateral project of technical co-operation between the latter university and the Agricultural University at Wageningen. The aim of the project is a botanical and agricultural survey of cultivated and wild food plants of Ethiopia. Under the general guidance of the Dean of the College of Agriculture, HSIU, Dr Makonnen Kebret, the work was carried out with Ato Taddesse Ebba as a counterpart in the Plant Sciences Department headed by Dr Dawit Deguefu. Extensive collection trips were made through most of the Empire, some together with students of the College, notably with Ato Hailu Gebre.

In September 1968 a start was made in assessing the collection of ca 5550 numbers of exsiccatae and seed samples at the Laboratory of Plant Taxonomy and Plant Geography, section Tropics and Subtropics, headed by Prof. Dr H. C. D. de Wit.

From November 1966 till September 1969 the work was sponsered by the International Technical Assistance Department of the Netherlands' Ministry of Foreign Affairs. From September 1969 on, the Agricultural University offered a temporary basis to continue it as a staff member at the Department of Tropical Crops, headed by Prof. Dr J. D. Ferwerda, in close co-operation with the Laboratory of Plant Taxonomy and Plant Geography, which provided accommodation till the end of 1973.

Since it was impossible to cope with all material and data, it was decided to concentrate on systems of agriculture and on pulse crops, leaving other groups of useful plants (fat and oil producers, condiments and spices, carbohydrate producers) to others who are planned to continue the project.

The present book is the result of a co-operation between the College of Agriculture at Alemaya, and the Laboratory of Plant Taxonomy and Plant Geography and the Department of Tropical Crops at Wageningen. It appears as a joint publication, the first volume of a series on Ethiopian edible plants.

Dank zy het Licht der Zonn', 't welk nevens dat der Maane
De moeder de Aarde ontdekt, opdat ze een doortogt baane
En, door haar Sleutelen, zich voor 't gewas ontsluit';
Dies stort zij eenen Hoorn van zeldzaamheden uit ...
Zy laat zich niet bepaalen
Aan 't geen natuur in elx saizoen of luchtstreek teelt;
Maar word door Arbeid en door Kunst geprangt, gestreelt
Tot Water, Vuur en Glas, de broejing en de luchten
De groei bevorderen aan planten en aan vruchten.
Dus kan Europe hier den Ommekring van 't Jaar
Braveeren met Feestoen gevlochten by malkaêr
Uit de alleredelste Gewassen, Vrugten, Bloemen
Daar Azie, Afryke en Amerika op roemen ...
Hier, nevens duizenden, Heer Cliffords yver loonen
En, door Linnaeus Pen, zich aan de waereld toonen.

From 'Verklaaring van de Tytelprent' by J. Wandelaar in Linnaeus's Hortus Cliffortianus (1737).

1 Introduction

1.1 Materials and methods

To obtain a representative idea of the crops and plants used for food, specimens and seed samples were collected in fields, gardens, at market places and from the wild. Especially market places proved important to obtain a representative view of the variation within the different crops. About 80 market places were surveyed, most of them several times during different seasons to obtain an idea of the succession of crops. Mrs J. M. C. Westphal-Stevels materially contributed to the surprisingly rich and varied collections.

A great number of seed samples was sown in the small Hortus Botanicus Alemayensis and by means of the resulting plants the different stages of growth have been preserved. More than 800 seed samples were sown in Wageningen, both outdoors and in greenhouses, to obtain the whole life-cycle of the involved taxa. Facilities were made available by the Laboratory of Plant Taxonomy and Plant Geography and the Departments of Tropical Crops, Plantbreeding and Genetics. This resulted in more than 3000 numbers of plants collected with the help of the Herbarium staff and several students. Of each seed number seedlings, flowering and fruiting material as well as seeds were dried and/or preserved on spirit, whereas the plants themselves were studied during their development.

All collected specimens (ca 8700), including more than 6100 numbers of cultivated taxa are conserved in the Wageningen Herbarium (WAG). A duplicate set of each number of the entire collection made in Ethiopia is conserved in the Herbarium of Alemaya. Unless otherwise indicated, the collection numbers cited are those of the Wageningen Herbarium, under WP (Westphal–Westphal-Stevels collection) or SI (Seegeler collection). Sporadically reference could be made to specimens of the J. J. F. E. de Wilde collection indicated by J. J. de Wilde.

The descriptions are based on specimens grown in Ethiopia or raised from seed at Wageningen. Since the height of the plants is most variable, reference is made solely to their general habit (shrub, climber, or otherwise). For more information on the size of the plants see Purseglove (1968). Hardly any information is available on rooting depth. Each description is accompanied with a line drawing.

The colour chart of the Royal Horticultural Society London (1966) has been used to distinguish the cultivars of *Phaseolus vulgaris* on the colour of the seed coat. To describe leaf shapes, the proposed standardization of terms for flat shapes of the International Association for Plant Taxonomy (Taxon 11(5), 1962: 145–156) has been

followed. For other botanical terms see Jackson (1965) and Lawrence (1966).

The somatic chromosome numbers for the taxa dealt with are fairly well known. Only chromosome counts on Ethiopian material are mentioned (see Frahm-Leliveld, 1957).

The protein contents mentioned for each crop are from literature, and refer to the crops in general and not to special cultivars. Their ranges for the different plant parts are fairly well known. The data, in percentages of fresh weight, are mainly from Purseglove (1968) and Terra (1966) and solely intend to give a general idea. Only Darby (1959) deals with Ethiopian pulses. The protein content of the Abyssinian pea was determined by the Department of Human Nutrition of the Agricultural University at Wageningen.

Data on photoperiodicity in literature for pulse crops are often confusing or even contradictory. Purseglove (1968), for instance, mentions long- and short-day cultivars in *Dolichos lablab*, whereas in fact the hyacinth bean is a quantitative short-day plant. Stanton (1966) refers for *Phaseolus coccineus* to long-day, day-neutral and short-day cultivars, which is most unlikely: he means that this species exhibits short-day as well as day-neutral types. This confusion is also apparent from the frequent reference to long- and short-day cultivars in *Oryza sativa:* Vergara & Lilis (1967) have demonstrated that rice is a quantitative short-day plant.

1.2 General remarks

Most crops cultivated in Ethiopia, such as t'ef, wheat, barley, niger seed, chickpea and lentil are composed of landraces. According to Sneep (1972)[1] a landrace is a population of lines or a cross-pollinating population, shaped in a certain region under the prevailing conditions of climate, soil and agricultural practices, and which has not been subjected to selection or to superficial mass selection only.

The following terms are frequently used in the text.

Variety (var.) in the sense of botanical variety (varietas). For variety in the sense of 'cultivated variety' the term cultivar (cv.) is used.

Cultivar (cv.) denotes 'an assemblage of cultivated plants which is clearly distinguished by any characters, and which, when reproduced, retains its distinguishing characters' (International Code of Cultivated Plants, 1969, Art. 10).

Cultivar-group (cv.-group) denotes a distinct group of cultivars. It has no official status under the Code. Example: *Vigna unguiculata* cv.-group Unguiculata refers to the cultivars of common cowpea, *V. u.* cv.-group Biflora refers to the cultivars of catjang cowpea, whereas *V. u.* cv.-group Sesquipedalis denotes the cultivars of yard-long bean.

Tropics The region between the tropics of Cancer and Capricorn.

1. Sneep, J., 1972. Undergraduate Plant Breeding Course, Agricultural University, Wageningen: 12-13.

Subtropics The regions between the tropic of Cancer or the tropic of Capricorn and the 10 °-isotherm of the coldest month.

In the Ethiopian language most consonants sound approximately like their English equivalents, thus: *sh* as in ship, *j* as in joke. Sometimes *j* is also voiced like *sh* or *g* as in French gendarme. Next to *ch*, *k* and *t*, which are aspirated, there exist in Amarinia *ch'*, *k'* and *t'* which are not. In these consonants aspiration is avoided by closing the vocal chords, and to open them again only when the sound is being pronounced ('explosive' pronunciation). See, for instance, ch'at, k'olla, t'ef. In vowels frequently signs are used to indicate a difference in sound. This is not applied in the text to avoid further complications.

The designation of cultivars is based on seed characteristics. Plates of seeds of various cvs are included to demonstrate the variation encountered. The plates should be consulted together with the description of the cultivar concerned and the line drawing of the species (or cultivar-group) to which the cultivar belongs. A colour plate with a mixture of seed types has been included (see cover).

The drawings made by Miss H. G. D. Zewald and Mrs P. Verheij-Hayes are kept in the Wageningen Herbarium (WAG). They are 6/5 times the size of the reproductions.

The topographic map does not aim at completeness. Regions, rivers, lakes, mountain peaks, roads and the most important towns and villages are indicated.

Chapter 4 deals with the taxonomy of wild and cultivated (= domesticated) taxa. Strictly speaking this chapter is not confined to the treatment of Ethiopian pulses only. It is the result of some reflexions on the taxonomy of these crops and of cultivated plants in general. Since more contributions on cultivated plants of Ethiopia are to be expected in a near future, it seemed useful to discuss the role of plant taxonomy as regards research in cultivated plants in the context of this study. Plant taxonomy, apart from its theoretical aspects, is closely linked with numerous aspects of applied botany, and it is an important tool in mastering the diversity of wild and cultivated taxa. Designating a taxon by its correct scientific name is very much more than calling something or even a human being by its own name. There is a very important difference to be noted. A human being has its own 'name', but this name does not tell anything about the person who possesses it. The name of a taxon makes it accessible for exchange of facts and information of any kind and in addition the name stands for the delimitation of the taxon which it represents. Like 'traditional' taxonomy, 'cultivar' taxonomy aims at the delimitation, classification and naming of taxa. As a result of crossing experiments new taxa may be created by which the plant breeder disturbs the existing order formerly created by the taxonomist.

2 Physical and biological environment

2.1 Geology

The geological structure of Ethiopia shows an extremely folded and foliated basement of pre-Cambrian rocks overlain by sub-horizontal Mesozoic marine strata and Tertiary basalt traps. The entire series was uplifted in the Upper Eocene as part of the Arabo-Ethiopian swell, across which later on rifting gave rise to the Rift system (Mohr, 1962). The pre-Cambrian rocks, known as the Crystalline Basement, are exposed in the peripheral regions of the country and are found in the northern part of the Ethiopian Highlands as far as Eritrea, along the eastern escarpment of these Highlands, in Wellega, in the southern regions, in the Chercher and Harar regions, and in the deep valleys of the Abbay and Didessa river.

During the Palaeozoic no deposition took place and the whole of the Arabo-Ethiopian massif formed a stable landmass subject to denudation, resulting at the end of the era in near-peneplanation of the ancient pre-Cambrian mountain ranges (Mohr).

In the Mesozoic era extensive areas of eastern Africa subsided and large deposits were left above the Crystalline Basement in Ethiopia. The Triassic Adigrat Sandstones are found in the Adigrat region and upper Tekkezze basin, along the eastern escarpment between Adigrat and Ankober, and in the valleys of the Abbay, Awash and upper Webi Shebele; the Jurassic Antalo Limestones are encountered around Mekele, the Abbay valley and over extensive areas of the Eastern Highlands to the Juba and Webi Shebele valleys; the Cretaceous period is marked by deposits of the Upper Sandstones which crop up in the south of the Eastern Highlands and the Ogaden (Huffnagel et al., 1961; Mohr, 1962).

At the end of the Mesozoic and the beginning of the Tertiary the Horn of Africa emerged when subsidence processes came to a halt. The large-scale major uplift in the Upper Eocene of the Ethiopian Swell and surrounding areas gave, later on, rise to the Rift system. At the same time, and immediately following this uplift, extensive volcanic activity produced heavy basaltic lava layers (the Trap Series with the Ashangi and Magdala Groups). In the Quarternary deposits of many types have been formed, including the Marine Deposits, the Continental Deposits and the Aden Volcanic Series (Mohr, 1962).

2.2 Topography and topographic regions

Characteristic for the Ethiopian topography is the pronounced difference in hot

lowlands ('kolla': sea level – 1800 m) and cool highlands ('woyna daga': 1800–2400 m, and 'daga': over 2400 m). Ethiopia consists primarily of two major highland regions separated by the Riftvalley and bounded on the east, south and west by lower areas. However, only limited areas of the country can be defined as true lowland and these areas are all situated on the borders of Ethiopia. Most of the country is well over 500 m above sea level (Last, 1962).

The following main topographic regions can be distinguished.

1. *Ethiopian Highlands* They extend from Eritrea to Kenya, and are entirely bound by escarpments except for the northern extremity which continues into the Sudan. The plateau is a high and dissected tableland with average elevation between ca 1500–1800 m, but considerable portions of it are much higher and elevations over 4000 m occur (such as Mts Ras Dashan, Guna, Tola). Erosion has been considerable, giving rise to valleys with steep slopes and isolated flat-topped massifs ('ambas'). The eastern escarpment follows more or less the meridian of 40 °E from Eritrea till the Awash where it curves south-southwest and continues to the Kenyan border. In the north its general elevation is 2100–2400 m, towering above the lowlands ca 1200 m below; in the centre it is broken by the Awash valley some 1000 m lower, forming one of the few easy gateways to the plateau. In the south as a rule it is lower, except for the region of the lakes Abaya and Chamo. The western escarpment is, as a rule, less high and abrupt, and considerably more broken (Logan, 1946). Several units are distinguishable within this topographic region of which the Abbay Trough is spectacular since its gorge (in some places some 2000 m below the plateau level) forms a formidable barrier to the north-south communication (Last, 1962).

2. Eastern Highlands and Somali Plateau They are bound in the west and north by a continuous escarpment from the Kenyan border to north Somalia. In its southern part the escarpment is ca 1800 m high, increasing northwards up to 3000 m near the Chilalo massif in Arussi and decreasing in north-eastern direction with an average elevation from 2400 m to 1800 m near Jijiga. The outer face is abrupt and high and rises 600 to 1200 m above the adjoining country. From the escarpment the Eastern Highlands gently slope south-eastwards to the Indian Ocean. Only the higher portions are in Ethiopia; they are much eroded and consist of large massifs and ranges of hills in a series of more or less parallel narrow plateaus. The highland areas above 1600–1800 m are considered to belong to the Eastern Highlands. The lower regions belong to the Somali Plateau and are characterized by vast monotonous flat lands. Several units are distinguishable, such as the Bale Massif mainly above 3000 m with several high peaks (Mt Batu), and the Ogaden Low Plateau between 1000 m and 500 m (Last, 1962; Logan, 1946).

3. Riftvalley and Danakil region The southern part of the Riftvalley, enclosed by the escarpments of the above mentioned highland regions, contains a chain of lakes extending from Lake Ziwai (ca 1600 m) to Lake Chamo (ca 1200 m) in the south. Further south, on the Kenyan border, are Lake Chew Bahir (ca 900 m) and Lake Rudolf (ca 350 m). North of Lake Ziwai the Riftvalley swings to the north-east and then gradually opens into the Danakil Plains. These plains are bordered by the escarp-

ments of the Ethiopian and Eastern Highlands and the Danakil Alps near the Red Sea. In the northern part of the Danakil Plains is the Kobar Sink depression, ca 100 m below sea level (Last, 1962; Logan 1946).

4. Red Sea Coastal Plains In the north this area is immediately east of the plateau. South of Massawa it lies east of the Danakil Alps as a narrow strip along the shore (Last, 1962).

5. Sudanese Lowlands, including western foothills and Omo Trough Along the foot of the western escarpment of the Ethiopian Highlands plain-like country gradually slopes towards the Sudan. In the north these plains are wide, towards the south, to the Abbay, narrow plains are separated by long spurs of highland. The Baro-Akobo Plains are, structurally, part of the Sudanese Plains, whereas the Omo Trough belongs to the Riftvalley system (Last, 1962).

2.3 Climate

Ethiopia lies entirely within the tropics, between latitudes 3 °N and 18 °N, and between the meridians of 33 °E and 48 °E. Topography has a decisive influence on rainfall and temperature. Weather conditions are often very variable. In most years the terms 'wet season', 'dry season', 'small rains', 'big rains' reflect the actual condition of the weather, but their timing is not so fixed as is believed. This is especially true for the period from mid-January to June, when the rainfall may vary considerably from year to year at a particular place (Huffnagel et al., 1961).

2.3.1 Pressure and wind conditions

During November to mid-March high-pressure cells over the eastern Sahara and Arabia, together with a low-pressure cell over central Africa south of 5 °N, dominate Ethiopia, resulting in dry north-eastern currents. Occasionally cold bursts from northern temperate latitudes penetrate south, and with the southern movement of the Arabian high-pressure cell, resulting in south-eastern moist trades, scattered precipitation occurs. By mid-March the Saharan and Arabian high-pressure cells are weakened and over the central Sudan a low-pressure cell develops. North of 12 °N the area is still dominated by the Saharan and Arabian high-pressure cells, and north to north-east winds persist. The Horn of Africa is influenced by east and south-east winds during April, but in May the monsoon becomes established. An intertropical convergence zone (I.T.C.Z.) is than situated over the southern Sudan, southern Ethiopia and Somalia, producing frontal precipitation. During June–August[2] low-pressure cells are present above the Sudan and Arabia, and the dominant feature is the

2. It is incorrect to use terms like winter, spring, summer and autumn for tropical regions. Here I am following Delliquadri (1958) who defined the seasons of the year as follows: December-February: 'winter'; March-May: 'spring'; June-August: 'summer'; and September-November: 'autumn'.

movement north and south of the I.T.C.Z. South of 18 °N south-western currents originating from the south Atlantic Ocean are the main source of moisture for the Sudan and Ethiopia. During September–November the southern margins are influenced by gusts of moist Indian Ocean air, whereas the southern retreat of the I.T.C.Z. causes the second rainfall maximum to Somalia, south-eastern Ethiopia and Kenya (Delliquadri, 1958; Kebede Tato, 1964).

2.3.2 Rainfall and rainfall regimes

Average annual rainfall decreases from the south-western margin of the Ethiopian Highlands eastwards to the Horn of Africa and north-eastwards to Eritrea.

The highest isohyetal values are found in the south-west where the 2000 mm isohyet is closely encircled by the 1800 mm and 1500 mm isohyets. The Ethiopian Highlands and the Eastern Highlands are outlined by the 950 mm isohyet with the higher mountains east of Lake Tana, east of Lake Abaya and the region around Bekeksa (Arussi-Hararge) standing out as islands of higher rainfall (1500–1800 mm). In Eritrea the eastern slopes fall within the 950 mm isohyet with most stations recording rainfall amounts in excess of 1000 mm. Enclosed within the 450 mm isohyet is a transitional zone including most of the Sudan Plains south of 14 °N, the eastern and southern slopes of the Ethiopian Highlands, parts of the Somali Plateau, and the Riftvalley north of Lake Shala and south of Lake Abaya. Enclosed within the 150 mm isohyet are south-east Ethiopia, the Danakil Plains and parts of Eritrea (Delliquadri, 1958).

Rainfall, except for the western provinces, is extremely variable for the dry months and should be considered with great care when looking at the annual mean (Kebede Tato, 1964). The seasonal character of the rainfall is equally important. Areas which have their periods of rainfall as well as dryness in the same months, irrespective of the total amount of rainfall, are subject to the same rainfall regime.

The following rainfall regimes are important for agriculture.

1. Regime with maxima in March–May and June–August This regime is typical for the Ethiopian Highlands (except for the western part), the Eastern Highlands (both with a 950–1500 mm annual average, over 2000 mm in the south-west), the Riftvalley north of Lake Abaya (450–950 mm annual average) and the Danakil Plains (150–450 mm annual average). A short transitional period, marked by a decrease in rainfall, occurs around May. The period of June-August records the heaviest rain, while that of December–February is as a rule the dry season with only small amounts of precipitation.

2. Regime with maximum in June–August Most of the eastern Sudan north of 8 °N and portions of the western Ethiopian Highlands show only one rainfall maximum, usually in August. The rains of March–May continue without a notable break into those of June–August. In the northern part 75–80 % of the rainfall falls in the period of June–August and little is recorded in the period of March–May, while near the southern margins and in the western Ethiopian Highlands the June–August rains

account for 50–60% and those in March–May for 15–20% of the yearly total (annual average for western Ethiopia 450–1500 mm). December–February is the dry season.
3. Regime with maxima in March–May and September–November It is found in the Horn of Africa, south Ethiopia and north Kenya. The period of March–May contributes 50–60% and that of September–November 25–35% to the yearly total (being 150–950 mm for the Ethiopian region). The other two periods are the dry seasons.
4. Regime with maxima in December–February and June–August This regime extends north from 15 °N along the eastern slopes of the Eritrean part of the Ethiopian Highlands. The double maximum contributes 55–70% to the yearly total (being over 1000 mm in the southern part), with the rest equally divided between the periods March–May and September–November (Delliquadri, 1958).

2.3.3 Temperature

The lowlands show the normal variation in temperature for these latitudes: coldest month January, hottest May. At higher elevations with higher rainfall as well variations in cloudiness affect the temperature regime. In the highlands the diurnal variation in temperature during periods of rainfall is about 6 °C, whereas in dry periods it frequently is as much as 22 °C. All areas between 1300 and 2100 m have maximum temperatures rarely rising above 25 °–28 °C. In the period between November and the end of January night frost occurs above 2100 m, in sheltered places even at lower elevations (Huffnagel et al., 1961; Last, 1962).

With a few exceptions the period of March–May is the warmest season. In April the Ethiopian Highlands and large parts of the Eastern Highlands are surrounded by the 25 °-isotherm which, for the most part, has taken over the place of the 20 °-isotherm of January. In large parts of Ethiopia minimum average temperatures occur during June–August, due to heavy rainfall and high cloudiness. In south-east Ethiopia average temperatures are also at their minimum during this period, due to heavy cloud cover. In July the 35 °-isotherm dominates the Red Sea–Gulf of Aden littoral.

During the periods of September–November and December–February higher maximum and minimum temperatures occur due to cloudlessness. For the Ethiopian and Eastern Highlands an increase in temperature of several degrees is noted, but it only slightly affects the highlands isothermal pattern (Delliquadri, 1958).

The largest changes in average monthly temperature occur along the coast, in the lowlands and plains, and on the slopes bordering the highlands; the smallest changes have been noticed over much of the Ethiopian and Eastern Highlands (Delliquadri, 1958).

2.3.4 Climatic regions

Largely based on Köppen's system of classification the most important climatic regions are the following.

1. BW or desert climate Characteristic are low rainfall, high temperatures and high potential evaporation. It is found in north Eritrea, the Danakil region and south and south-east Ethiopia.
2. BS or steppe climate It is transitional between the BW climate and the Cw or Aw climates, and shows higher rainfall and slightly lower temperatures than the BW climate. It is found in south-west Eritrea, along the eastern escarpment of the Ethiopian Highlands, in parts of the Riftvalley and in the middle ranges of the Somali Plateau extending from Somalia into south Gamu Gofa.
3. Cw climate It is typical for large parts of the Ethiopian Highlands as well as for the Eastern Highlands. Average monthly temperatures do not change very much during the year whereas the average annual rainfall varies from ca 950 mm to over 1500 mm. December–February is the dry period. Most Ethiopian people live in the area dominated by this climatic regime.
4. Cm climate The period December–February is not entirely dry and average annual rainfall varies between 1500 mm to over 2000 mm. This climate occurs in parts of Wellega, Illubabor and Kefa (between 1650–2250 m), as well as in the higher parts of Gojam and south-east Begemdir.
5. Aw or savanna climate December–February is the dry period. It is found in parts of the Eastern Highlands and western Ethiopia (including low and highlands).
6. Am climate It differs from the Aw climate in the annual amount of rainfall (over 1700 mm) and a shorter dry season. The temperature regime is similar except for the lower temperatures due to altitude. It occurs in parts of Illubabor and Kefa at ca 1500 m, and includes the area of the wild coffee forests (Delliquadri, 1958).

2.4 Soils

Three types of parent rock important for soil formation can be distinguished: (a) the granites of the crystalline basement which tend to form shallow, sandy soils; (b) the volcanic rocks, such as basalts, which tend to produce fertile loams, generally red in colour, but sometimes black; and (c) the limestones and sandstones which form shallow, poor, sandy soils (Last, 1962).

The work of Murphy (1959, 1963, 1968) has supplied much new information on Ethiopian soils, but he gives no classification and soil types are mainly distinguished by their colour and chemical properties. Huffnagel et al. (1961) depicted a map of soil regions, adopted from Dainelli (1943), on which areas are outlined based on relief and origin of parent material, but no classification has been attempted. Useful information on Ethiopian soils has been supplied by d'Hoore (1964). As far as possible his elements and associations are translated into the names of the soil orders of the new U.S.D.A. Soil Classification (7th approximation, 1960) in delimiting the following, broadly outlined soil regions.
1. Soils of the Coastal Plains Here Aridisols are found ('Brown Soils', 'Desert Soils' and 'Sierozems').
2. Soils of the Danakil Plains and the Riftvalley The Danakil Plains have Aridisols,

with salinity occurring in the Kobar Sink. In the Riftvalley itself, west of Awash, Aridisols are found in association with Vertisols (in topographic depressions), whereas to the south also Inceptisols ('Brown forest soils') and Mollisols ('Chernozem') are present. The Awash river valley is an exceptional area in the Riftvalley with a large plain of alluvial soils (with Entisols) near Nazret where sugarcane is grown.
3. Soils of the Ethiopian and Eastern Highlands In the Begemdir-Wollo-Gojam-Shoa region Alfisols (mainly the suborder Ustalfs), Vertisols and Inceptisols predominate. The shallow soils among them are red to light red-brown on the mountains and hillsides, red-brown on the slopes, brown to dark in the rolling country, to nearly black in the lower parts. The red-brown to dark brown soils are excellent for agriculture, particularly for grain crops, which are found all over the highlands. Stony mountain slopes and lower parts are used for grazing. The major soil problems are erosion on slopes, lack of drainage in lower parts, a too high acidity and therefore a lack of available phosphorus (Huffnagel et al., 1961). In the Lake Tana Plain Entisols are found in association with Vertisols (in topographic depressions). The southwestern part is dominated by Oxisols, Ultisols and Vertisols. In the Eastern Highlands shallow Inceptisols are found; in the Chercher region of these highlands soils range from grey to brown and are often stony. Their fertility makes extensive farming possible, particularly on the slopes and in those valleys where drainage is sufficient. Erosion is serious here and cuts deep gullies in the steep slopes (Huffnagel et al., 1961).
4. Soils of the Abbay Trough In alluvial and colluvial material Vertisols and Inceptisols are found with, more to the west, Entisols in association with Vertisols (in topographic depressions).
5. Soils of the Somali Plateau This region has mainly Aridisols with areas of high gypsum content in the extreme south-east of the Ogaden.
6. Soils of the 'Crystalline Highlands' In the area of north Eritrea, west Tigre and north Begemdir soils are stony, shallow and low in productivity. They belong to the Orders Ultisols and Alfisols, which are in the extreme north even more rocky and shallow, whereas to the west dry Vertisols (in topographic depressions) and Inceptisols (suborder Xerochrepts) are found. In western Wellega soils are deep and belong to the Orders Oxisols and Ultisols, and in south Sidamo mainly Aridisols occur.
7. Soils of the Sudanese Lowlands Here are flat Vertisols; in Illubabor also Entisols are present.

2.5 Natural vegetation

The first satisfactory geobotanical survey of the area is by Pichi-Sermolli (1957) who already in 1955 described the vegetation types of the arid and semi-arid zones of Ethiopia. The Vegetation Map of Africa (1959) and the Grass Cover of Africa (1960) are based on his studies as far as Ethiopia is concerned. The following vegetation types can be distinguished.
1. Desert vegetation Some areas in the Danakil Plains and towards Lake Rudolf show so poor a vegetation that they may be regarded as desert.

2. Semi-desert and steppe vegetation It varies from steppe with perennial undershrubs, herbs and grasses through semi-desert and scrub where the vegetation consists mainly of an open formation of grasses, ephemeral herbs and low thorny shrubs (like *Acacia bussei, Boswellia carteri, Commiphora, Grewia, Aloë*) into semi-desert and *Acacia.* Here small trees of *Capparis, Cadaba, Maerua, Boscia* are found, spiny *Euphorbia, Boswellia, Terminalia praecox, Salvadora persica,* and succulents like *Aloë, Sansevieria* and *Caralluma.* These types are encountered in the lower regions of Eritrea, in the Danakil and south-east Ethiopia.

3. Savanna It is found in the Riftvalley, west Ethiopia, south Sidamo and elsewhere. Simplified, its chief characteristic is the occurrence of short or tall grasses with scattered small trees mostly less than 8 m high. Sometimes tree density increases when it passes into woodland (usually *Acacia* woodland) wherever conditions are more favourable. In the *Acacia* savanna *A. senegal, A. seyal* and *A. spirocarpa* are prominent. *A. abyssinica* and *A. etbaica* come in at higher altitudes. Other associates, for instance, are *Carissa longiflora, Dichrostachys glomerata, Dobera glabra,* species of *Balanites, Capparis, Grewia,* while many grasses are represented like species of *Aristida, Cenchrus* and *Chrysopogon,* most of which are less than 50 cm tall. The *Combretum – Terminalia* savanna is widespread in west Gojam and west Wellega, but occurs also elsewhere. Typical, for instance, are *Combretum collinum, Terminalia brownii, Gardenia lutea, Piliostigma thonningii, Stereospermum kunthianum.* Grasses are mostly 1–2 m or more high with *Themeda triandra* and *Hyparrhenia* spp. predominating. Characteristic for this savanna type are the formations of lowland bamboo thickets *(Oxytenanthera abyssinica).*

4. Montane evergreen thicket and scrub On the slopes of the Ethiopian and Eastern Highlands this vegetation type is found between ca 1000 m and ca 2400 m. It consists of evergreen or semi-evergreen shrubs, big bushes, small trees and climbers with occasionally larger trees. Most common are, for instance, *Bersama abyssinica, Buddleja polystachya, Carissa longiflora, Cordia africana, Croton macrostachys, Euphorbia candelabrum, Euclea schimperi, Maesa lanceolata, Myrsine africana.*

5. Montane savanna It is found in the woyna daga and lower part of the daga of the Ethiopian Highlands (excluding the south-western part) and the Eastern Highlands between ca 1800 m and ca 2800 m. This savanna type deviates from the other type mentioned by its ecology and floristic composition. Probably this vegetation type developed from dense forest formations under the influence of man. It consists of a more or less dense herbaceous layer of 30–80 cm high composed of *Gramineae* and *Cyperaceae,* together with scrub and perennial herbs.

6. Montane dry evergreen forest Although now much reduced in extent, this community comprises valuable timber forests. Characteristic are *Juniperus procera* (mainly between ca 2200 m and ca 3300 m) and *Podocarpus gracilior* (mainly between ca 1500 m and ca 2200 m). The most frequent associates of these are, for instance, *Ekebergia rueppelliana, Olea africana, Pygeum africanum.* At higher elevations *Erica arborea, Hagenia abyssinica, Hypericum lanceolatum* come in.

7. Montane moist evergreen forest It is present in south-west Ethiopia. It is charac-

terized by high forest of 2 or 3 storeys. The principal high trees, for instance, are *Aningeria adolfi-friederici, Bosqueia phoberos, Manilkara butigi, Mimusops kummel, Morus mesozygia.* In the lower storey smaller trees like *Galiniera coffeoides, Teclea nobilis,* shrubs like *Coffea arabica* and the tree-fern *Cyathea manniana* are found.
8. High level bamboo forest Between ca 2600 m and ca 3000 m almost pure stands of *Arundinaria alpina* are found in Shoa, Kefa, Gamu Gofa, Sidamo, Bale and Arussi. It may be associated with, for instance, *Buddleja polystachya, Erica arborea, Hypericum lanceolatum, Rapanea simensis.*
9. High mountain vegetation It occupies the upper slopes and summits of the highest mountains. This vegetation type begins above the *Hagenia-Hypericum-Rapanea* association at ca 3300 m, and is characterized by, for instance, *Erica arborea, Lobelia rhynchopetalum, Helichrysum* spp., *Alchemilla* spp. Above ca 4000 m afro-alpine formations appear with *Lobelia rhynchopetalum, Senecio farinaceus.*
10. Coastal formations The principal types are the plant communities of the coral beaches, sandy shores, estuaries, dunes and mangrove swamps. On the coral beaches saline plants like *Atriplex farinosa, Limonium axillare, Salsola* spp. and *Suaeda* spp. are present, whereas in the estuarian vegetation *Suaeda fructicosa* is encountered. The mangrove swamps are extremely locally and consist of, for instance, *Avicennia marina, Rhizophora mucronata, Sonneratia alba.*
11. Swamp formations Swamps are found in Chew Bahir, along the shores of the Riftvalley lakes and Lake Tana, north-west of Lake Abbe and in the northern Danakil Plain. Characteristic are in general *Cyperus papyrus, Phragmites australis* and *Typha* spp., whereas in the arid zone salt-resistant plants are found, especially *Suaeda monoica.*
12. Riparian formations These are complicated communities varying considerably. In the drier regions *Hyphaene* spp. are frequently encountered along the rivers and wadis (Gillett, 1941; Mooney, 1961; Pichi-Sermolli, 1955, 1957).

2.6 Ethnic groups and languages

Ethiopia represents a heterogeneous mixture of linguistic, ethnical and cultural types. Except for the Negro languages which belong to the Nilo-Saharan language group, all languages belong to the Afro-Asiatic language group (Greenberg, 1963). Linguistic affinity seems the best guide to ethnic distribution (Ullendorff, 1966). The following groups are found.
1. Semitic languages To this group belong the Amhara, Arabs, Argobba, Gofat, Gurage, Harari, the Tigré-speaking people of Eritrea, and the Tigrai. The Amhara and the closely related Tigrai, speaking Amarinia and Tigrinia respectively, dominate the country and constitute about one-third of the population (Lipsky, 1962). The Amhara are mainly living in Begemdir, Gojam and Shoa, and the Tigrai in Eritrea and Tigre. Both peoples are grain-plough agriculturalists.
2. Cushitic languages This is a most complex group and includes the Agau, Beja, the Burji-Geleba group, Danakil (= Afar), Galla, Saho, the Sidama group, and the

Somali. The Galla are the largest ethnic group comprising ca 40% of the total population, the Sidama group comes to ca 9%, and the Somali to ca 6% (Lipsky, 1962). The Galla are either pastoralists as the Borana in the south, or agriculturalists living in the Eastern Highlands and the central and western parts of the Ethiopian Highlands. The Sidama group lives in south-west Ethiopia and is engaged in ensat cultivation. The Somali and Danakil are pastoralists living in south-east Ethiopia and in the Danakil Plains respectively.

3. Negro languages This is a complex group of peoples comprising ca 6% of the total population (Lipsky, 1962). They are mainly living in the western lowlands near the border of the Sudan, and are agriculturalists or pastoralists (Cerulli, 1956). The Bako group, however, lives in the highland of west Gamu Gofa and some tribes of this group cultivate ensat (Jensen et al., 1959).

3 Agriculture

3.1 Agro-ecological regions

The main agro-ecological regions of the country, based mainly on Bunting (1963), are the following.

1. Central part of the Ethiopian Highlands It includes Shoa, Gojam, and also south-west Wollo, south Begemdir and eastern Wellega. Soils are mainly Alfisols, Vertisols and Inceptisols, the altitude ranges between 1800–3000 m, and the average annual rainfall varies between 950 mm and 1500 mm. It is a region of highly developed mixed agriculture where a simple plough and rotations including fallows and annual legumes are applied, often with contoured or even terraced fields. Broad valleys are used for dry season cropping and grazing. The main crops are t'ef *(Eragrostis tef)*, barley *(Hordeum vulgare)*, wheat *(Triticum* spp.*)*, sorghum *(Sorghum bicolor* and other spp.*)*, finger millet *(Eleusine coracana)*, niger seed *(Guizotia abyssinica)*, safflower *(Carthamus tinctorius)*, linseed *(Linum usitatissimum)*, chickpea *(Cicer arietinum)*, lentil *(Lens culinaris)*, pea *(Pisum sativum)*, horse bean *(Vicia faba)*, grasspea *(Lathyrus sativus)*. Many herds of cattle, sheep and goats are kept, which graze on fallow or valley land and consume part of the agricultural residues.

2. Lake Tana region It lies partly in Begemdir south of the escarpment and partly in Gojam. Much of the area is at high altitude (above 1500 m) and receives 950–1500 mm rainfall annually. It is in some ways similar to the central part of the Ethiopian Highlands, but it contains also the great plains around the lake with Entisols and Vertisols, which are suitable for both plant and animal production.

3. Northern part of the Ethiopian Highlands This is a highly dissected country in Eritrea and Tigre with less rainfall (450–950 mm annually) than in the central part of the Ethiopian Highlands, and with mostly less productive soils derived from basement complex rocks and sandstones. Wheat, barley, t'ef, sorghum and oilseeds, including groundnut *(Arachis hypogaea)*, are grown, but there is also considerable production of fruit and cotton *(Gossypium* spp.*)*, and of meat and milk, and of cattle, sheep and goats.

4. South-western part of the Ethiopian Highlands This region is situated at 1500–2400 m altitude in Wellega, Illubabor and Kefa. It is a high rainfall area (1500 mm–over 2000 mm without a real dry season), with Oxisols, Ultisols and Vertisols. Many crops are produced, including some of those grown in the central part of the Ethiopian Highlands, and in addition maize *(Zea mays)*, ensat *(Ensete ventricosum)*, yams *(Dioscorea abyssinica* and other spp.*)*, taro *(Colocasia esculenta)*, and especially

coffee *(Coffea arabica)*.

5. South-eastern part of the Ethiopian Highlands Included in this region are south-west Shoa, west Sidamo and Gamu Gofa at altitudes of 1800 m and higher, with mainly Alfisols, and with 950–1500 mm average annual rainfall. Many crops are produced, most important of which is ensat. Other tuber crops like yam, taro, Galla potato *(Coleus edulis)*, anchote *(Coccinia abyssinica)*, and potato *(Solanum tuberosum)* are also cultivated, and of the cereals barley is widely grown followed by wheat and t'ef. In the southern part terraces are no uncommon feature.

6. Eastern Highlands This area is situated in Sidamo, Bale, Arussi and Hararge at ca 1800 m and higher. Soils are mainly Alfisols and Inceptisols; average rainfall is between 950–1500 mm and in some areas as high as 1800 mm. In high Sidamo pastures are found up to 3000 m, together with barley and ensat. This region is particularly important for animal production. In Arussi and Bale wheat and barley are the prominent cereals (between 2000–3000 m), whereas in east Arussi and Hararge coffee and ch'at *(Catha edulis)* are prominent up to ca 2000 m together with sorghum, maize and beans *(Phaseolus vulgaris)*, and with wheat and barley at higher elevations. Along the western escarpment in Sidamo ensat is cultivated together with coffee (the latter up to ca 2000 m).

7. Southern Riftvalley and lake region This region includes parts of Shoa, Arussi, Sidamo and Gamu Gofa and continues as far south as Lake Chamo; it lies above 1200 m. South of Shashamane rainfall is often high (up to ca 1600 mm annually) but the distribution is unreliable since this area is on the boundary between the regions of rainfall maxima during the periods of March–May and September–November, and during March–May and June–August. The Riftvalley north of Lake Shala and south of Lake Abaya receives less rainfall and has higher temperatures. The predominant soils are Inceptisols and Mollisols. Of special interest is the coffee producing area of Yirga Alem–Wondo–Dila–Yirga Chaffe, which partly lies in the Riftvalley itself and partly on the escarpment of the Eastern Highlands. Other crops grown are ensat and maize.

8. Borana region The high Sidamo area slopes down to the south into the Borana region with parts situated below ca 900 m. Rainfall varies from 450–900 mm annually. It is the region of the cattle rearing Borana.

9. Middle and lower Awash region This region is situated in the rift country of Shoa, Hararge and Wollo between Nazret and beyond Tendaho, at altitudes from 1500 m to 500 m. Soils are mainly Aridisols, rainfall is uncertain and low, and evaporation rates are high. Cropping depends on irrigation from the Awash river and its tributaries. The chief crops are cotton, sugarcane *(Saccharum officinarum)* and sorghum. There are considerable areas of swamp and upland which are grazed seasonally by the herds of nomadic graziers.

10. Ogaden region For the greater part this area is below ca 600 m in a country too dry for crop production, although the soils are potentially fertile. Irrigation might be developed by making use of the rivers running into the Ogaden; in fact some irrigation schemes have been carried out like the Godere scheme. At present the Ogaden is a

region of nomadic graziers.

11. Western Lowlands Plains are found at the foot of the western escarpment and foothills of the Ethiopian Highlands below ca 1000 m, which gradually slope into the Sudanese plains. Temperatures are high and average annual rainfall varies from ca 1200 mm at Gambela to less than 150 mm in north Eritrea. Agriculture with or without irrigation is performed. Between the Setit and Angereb in north-west Begemdir, for instance, with an annual rainfall between 500–700 mm, rain-fed crops like cotton, sesame *(Sesamum indicum)* and sorghum are grown (Kline et al., 1969). The Baro river plain in Illubabor is potentially a very important area for agricultural production.

3.2 Ensat-planting versus grain-plough agriculture

The cultivation of ensat belongs to the hoe-culture of tropical Africa as opposed to the plough-farming represented in the central and northern part of the Ethiopian Highlands. It is a planting culture not so much because of the principal implement, the hoe or related tools, as because of the way of propagating the plant vegetatively. The ensat-planting culture is located in the south-western highland zone between ca 1600 m and ca 3000 m (Smeds, 1955), and ensat is grown for food in no other part of Africa but for south-west Ethiopia (Murdock, 1960; Purseglove, 1972). This area is characterized by a complex of cultural traits connected with the ensat cultivation, the so-called ensat culture complex area (Shack, 1963).

The people living in central and northern Ethiopia, however (either Semitic or Cushitic), prefer to cultivate cereals, pulses and oilcrops, and neglect tuber crops, vegetables and fruits. The plough is associated with this type of agriculture.

Stiehler (1946) stressed an important difference in the type of settlement between the two cultures involved. The ensat-planting culture is connected with a settlement pattern consisting of cultivated patches near dispersed homesteads, each with its own plot with ensat and other crops. This contrasts sharply with the village pattern in northern highland Ethiopia. Besides, the zoning of cultivated plants in south-west Ethiopia according to altitude goes hand in hand with a different settlement pattern. In the sorghum/maize zone (up to ca 1600 m) the village type of settlement is met with. In the ensat zone (ca 1600 m–ca 3000 m) the phenomenon of dispersed homesteads appears. The regional distribution of the ensat and the dispersed homesteads, however, do not coincide everywhere. On the Ethiopian Highlands a zone can be distinguished in which cereal-plough agriculture goes hand in hand with dispersed homesteads. The presence of this zone between the above outlined pattern of settlement and agriculture is probably due to the decline of the ensat-hoe cultivation in favour of the cereal-plough cultivation (Stiehler, 1946).

3.3 Systems of agriculture

Due to the many transitions and the great diversity among the types of agriculture in Ethiopia, it is not possible to distinguish clear-cut groups. Thus the classification into the seed-farming complex, the ensat-planting complex, shifting cultivation, and the pastoral complex is only rough.

3.3.1 The seed-farming complex

Characteristic for this complex is the reproduction of nearly all crops by seed. Important are cereals, pulses, oilcrops, and to a much lesser extent tuber crops. This complex is found in the Ethiopian Highlands (in particular in its central and northern parts), in the Eastern Highlands, and in the Konso and adjacent regions. As a rule it is practised by people with a Semitic or Eastern-Cushitic language. Grain cultivation practised in ensat regions is treated under the ensat-planting complex (3.3.2), whereas grain cultivation performed by shifting cultivators and pastoralists in the lowlands is discussed under shifting cultivation (3.3.3) and the pastoral complex (3.3.4) respectively.

3.3.1.1 The grain-plough complex of the central and northern Ethiopian Highlands

A striking feature of the grain-plough complex is that fruit trees, green vegetables and tuber crops are nearly absent, and the emphasis is on seed production and broadcast sowing. Putting seeds in holes is as a rule limited to certain garden plants. Many farmers in Begemdir and Simen even have no idea of vegetative reproduction (Simoons, 1960; for Gojam see Kuls, 1963).

The plough ('marasha') is a breaking plough, it does not turn the soil, but breaks it. Contour ploughing is usual and done three to four times (the first time in the dry season) before an adequate seedbed is obtained. After broadcasting the seeds are ploughed in. In most places, crude wooden ploughs are used with a small iron point which crumbles the soil, resulting in a better rainfall absorption and reduction of the speed with which water may start to run off (Huffnagel et al., 1961). Important is that the plough furrow contributes to the prevention of erosion by forming pockets which catch and hold water during heavy rains (Hailu Mengesha & Lee, 1960). In some highland parts numerous stones protect the soil against excessive evaporation. As the top soil is not turned over, grass roots and crop residues remain on top of it and protect the soil against erosion. Pure plough farming, however, does not exist, since additional hoeing implements are used (Huffnagel et al.)

Arable-pasture rotation By far the largest part of the highland is covered with a dense sod or heavy growth of bunch grass. Volunteer grass may enter the rotation of crops as often as every third year. Often the sod survives the cropping period and is extending again as soon as the land is left fallow. Many of the sod grasses are rhizo-

matous as well as stoloniferous. In general, erosion conditions are worse on grazing land than on crop land. There are indications that some farmers watch the natural succession of plants and await for the appearance of certain indicator plants before ploughing the land again. So, through the centuries a rotation of crops and sod grasses maintained the productivity of the land (Semple, 1945).

Live stock is kept throughout the year on natural pastures and stubbles. Supplementary feeding of forage or grain is not unknown. An arable-pasture rotation is applied, except where local conditions prevent the growing of crops. The system of keeping land under stocks is robbed of its full effectiveness, since the dung collected from fields and corrals is widely used as fuel (Huffnagel et al., 1961), so that the preservation of the soil productivity depends on grass.

Terracing and drainage Terracing is practised in parts of Tigre and in north-east Shoa. In south Tigre narrow terraces, often even less than one meter wide, are found on steep slopes; west of Adigrat they are very wide (Huffnagel et al., 1961). In north-east Shoa many slopes are inconspicuously terraced, both in the gorges and on the plateau (Buxton, 1949). According to Huffnagel et al. terracing is also frequent in parts of Gojam, but Kuls (1963) hardly found any there. There are no drainage-type terraces in this part of Ethiopia which, with an average annual rainfall between 950–1500 mm, creates a problem, especially since the rainfall is concentrated in a period of only about three months.

Drainage furrows are ploughed on probably 10–15% of the fields, usually at intervals of 3–7 m. They are 15–20 cm wide and deep (Huffnagel et al.).

Irrigation In several parts of the highlands irrigation is practised. In Tigre fields of barley, which comes as a second crop after the harvest in November–December of rain-grown t'ef, wheat or barley, are irrigated. Pulses, sometimes planted after the second barley harvest in February, are also irrigated and then harvested as late as April (Dove, 1890).

In Begemdir and Simen the irrigated plots are small and occur only along streams. The most intricate system of carefully dug irrigation ditches has been observed in an Agau village, where water is channelled by establishing diversion dams in irrigation ditches. Here, farmers supply irrigation water to their maize, barley, t'ef and chickpea fields by breaching the wall of the ditch, and when the field received enough water, they seal the wall again (Simoons, 1960).

In Wollo irrigation is applied to some extent in the highland valleys and on the east slopes of the escarpment by diverting flood water from the escarpment into the fields (Murphy, 1968).

In Gojam irrigation is not rare, but as a rule limited to plots of onions, chillies, tomato, Galla potato *(Coleus edulis)*, potato, etc. near the houses. Most irrigated fields serve the cultivation of barley, a salient characteristic for the region west of Debre Markos. Here irrigation water is brought from small rivers and streams, sometimes over several kilometers, through channels to the fields near the settlements, and distributed through minor channels over fields with barley (Kuls, 1963).

In north-east Shoa, irrigation is practised on the level shelves in the gorges. Along

some rivers a more elaborate irrigation system has developed here which provides water throughout the dry season. Its object is to ensure an early crop of barley to be harvested before the main rains start in June. The system has to be partly rebuilt every dry season, as the dams, constructed of stones and earth, are swept away during the rains. Close to each dam, water is diverted into a furrow in which it flows in a direction opposite to that of the river. From this furrow, minor channels branch off which can be opened or blocked at will (Buxton, 1949).

Around Bako, in west Shoa, irrigated onion and maize fields occur in the dry season, whereas in every valley west of Nekemte in Wellega irrigated plots with maize and sorghum are found.

Cultivation practices including crop rotations The use of a rotational system of farming with a seasonal fallow of the land, and the inclusion of a legume crop are most probably responsible for the sustained though low yields. Soils are clayey or loamy in texture, being black or red, and rich in phosphorus and potassium. Situated in the woyna daga (1800–2400 m), they are suited for the production of grasses, legumes and small grains. But any deviation from the traditional rotation, fallow included, results in a large decrease in yield or even crop failure. This may indicate that the nutrients of these soils are in a very delicate state of balance, nitrogen being the most critical element (The Agriculture of Ethiopia, 1954). After centuries of cultivation they are generally still in good condition, indicating that the rotation systems and customary practices have been satisfactory (Omero Sabatini & Samuel, 1969).

In the central and northern Ethiopian Highlands t'ef is the most important cereal (Purseglove, 1972). It thrives well during a short and cool rainy season and is tolerant of water-logged soils. If conditions are not extreme, barley and wheat also grow well, while highland sorghum is suitable if the rainy season is long enough (Harrison et al., 1967). T'ef is a unique crop in the Ethiopian ley system. Agronomically it is more a ley grass than a grain crop, combining soil-restoring and fodder-producing properties of a ley grass with food production (Ruthenberg, 1971). This is, however, a bold assertion. After the harvest of t'ef the stubbles are grazed by cattle. At the end of the dry season they are ploughed under to prepare the seedbed for the next crop.

In *Begemdir and Simen* sowing may start already early in April with the first rains, but more often in May and June. Frequently, another crop is sown in September to take advantage of the late rains. Usually one kind of seed is sown but sometimes the farmer mixes several kinds of seeds, or first sows one and then, after a few days, a second, or rarely even a third. The most common mixture is wheat and barley. Other mixtures include pea and horse bean; t'ef and garden cress *(Lepidium sativum)*; Egyptian lupin *(Lupinus albus* cv.-group Albus*)* and t'ef, linseed or barley; sorghum and finger millet *(Eleusine coracana)*; sorghum and chickpea; safflower and chickpea; safflower and t'ef; sorghum, sesame and common bean; maize and gourds. It is common practice to grow two successive crops on the same field in a year. Almost any crop may be used for the late crop, but emmer *(Triticum dicoccum)*, other wheat

types, barley and lentil are commonly found in Simen (Simoons, 1960).

To control the growth of bushes, fields are burned after the harvest, either every year or every few years. On black soils the rotation seldom includes a fallow period (Table 1: 1); chickpea and niger seed are included to restore soil fertility. On red soils a field is fallowed every few years: a common rotation here gives Table 1: 2. Fallowing comes no sooner than necessary and although farmers recognize the necessity of the fallow third year, they in fact cultivate a field every year until it is exhausted. Domestic animals graze the fallowed land. Harvesting time is the dry season for crops sown in March to May from September to February–March, for crops sown late in the rainy season the end of the dry season (Simoons, 1960).

In *Tigre* and *Eritrea* the important crops are wheat, barley, t'ef, sorghum, oilcrops including groundnut (in Eritrea), and various pulses. Coffee is found in Eritrea in the area with rainfall over 1000 mm annually (Delliquadri, 1958).

In *Gojam*, between 1800 and ca 2600 m, t'ef is the most important crop. Seedbed and cultivation are intensively cared of. Ploughing is repeated several times before the seedbed is ready, furrows are drawn by ploughing perpendicular to the wind direction, some weeks after seeding the fields are weeded, and finally the crop is harvested just before full maturity. Above ca 2400 m wheat and barley, and at ca 3000 m barley dominate. Since most irrigated fields are used for barley, this cereal may be even more important than t'ef. Finger millet is often cultivated between ca 1900 m and ca 2200 m. Of the pulses horse bean is found as high as 3200 m. Land on which horse bean does not grow very well is planted with Egyptian lupin. At higher altitudes pea is common, as in the woyna daga lentil and chickpea are important crops. Chickpea is grown in the dry season on Vertisols and is sown end September to begin October. The prominent oilcrops niger seed and linseed are found in the woyna daga up to ca 2500 m (Kuls, 1963).

Tuber crops do not play an important role, with two exceptions: in the daga zone of the Choke Mountains and Agaumedir potatoes are cultivated (planted in December–January). In Agaumedir many fields with Galla potato are present. Manuring is not restricted to gardens and small plots, but may include fields with barley, wheat or pulses, but in a rather haphazard way. The manured land is permanently cultivated; if necessary for the unmanured land a fallow may be inserted after 4–8 years of cultivation. In densely populated regions the fallow is reduced to 1–2 years. Quite often the same cereal is sown for 2–3 subsequent years on a field, after which a several year's rotation of cereals with pulses and oilseeds follows, but obviously there are no fixed rotations. For some rotations see Table 1: 3, 4 and 5. Since t'ef is sensitive to weed growth, it is exceptional to find it as the first crop after burning, which is frequently practised (Kuls, 1963).

Interesting is a type of rotation in strips practised in the daga region, based on three annually interchanging crops. In the Choke Mountains it mainly is a three strip system with two strips under crops and one fallow. Here the cropped strips usually have barley, wheat is less important, and Egyptian lupin is even less frequent. An important advantage of this system is that the stubble of the fallow strip can be used

for grazing till the end of the rainy season and till the time that the crop on the other strips is ready for harvesting. Especially in densely populated areas this increase in pasture land is important (Kuls, 1963).

Irrigated fields are permanently cultivated and manured as well (Kuls, 1963).

Harvest takes several weeks to some months. In the upper parts of the woyna daga it starts early in December and continues till February. The moment does not only depend on the crop, but also on the time of sowing since on large fields sowing is done in stages resulting in cereal fields with green and mature parts. Next to a marked vertical differentiation of agriculture, a horizontal differentiation can be distinguished, as a result of ethnic differences (Kuls, 1963).

Wollo is an important grain province: its higher parts produce t'ef, barley, wheat, horse bean and pea, at lower elevations t'ef and sorghum are more prominent. At the end of April fields with young barley were observed, especially around Lake Ashangi in north Wollo, which were probably irrigated.

In *north and north-east Shoa*, between ca 2400–3000 m, a sod rotation is applied which includes barley, wheat, some t'ef and pulses like horse bean, pea, etc. In the dry season long-fallowed grassland is broken with the plough, the sods are gathered into numerous heaps and set alight (soil burning) to kill the grass and the weeds, and finally the soil is spread again. After the onset of the main rains, at the end of June, the fields are ploughed again and sown: first barley and late in the main rainy season of June–September the other crops. Sometimes barley is also sown during the early rains (February–March), but in north-east Shoa the early crop rarely gives a good return and sometimes fails completely. The land on the plateau, after being cultivated for a few years, is kept fallow for a widely varying period that may be as long as 5–7 years (Buxton, 1949).

In the *Yerer-Kereyu Highlands of Shoa* east of Addis Abeba cereals and pulses rank first. The main cereals are t'ef, wheat and barley. Chickpea, pea, lentil, horse bean, grasspea, niger seed, safflower and linseed also occur. It is a very important grain producing region. Barley and sorghum are sown during the small rains (March–April), followed by chickpea and horse bean, and in July quite often by some wheat. In the beginning of August again wheat is sown on black soils; chickpea or lentil follow end September on red soils. T'ef is planted mid-July on black soils. Pulses such as chickpea and lentil sometimes give two crops a year. On fields sown with chickpea and lentil in April, a second crop of grasspea or chickpea will be sown. Grasspea is usually cultivated on land which lay fallow that season. Pulses sown in April or at the end of September are harvested at end July or end December. Barley and sorghum, sown in April, are harvested mid-September and December respectively; wheat, sown mid-June or begin August, is reaped mid-November or December. T'ef is harvested early in January (Kuls, 1957).

Fields are often cultivated for at least two years with a cereal, followed by some of the pulses. On black soil wheat can be grown during four successive years, on red soil barley for only two years followed by horse bean, pea or chickpea. Grasspea is mainly used to improve the soil and as cattle feed (Kuls, 1957). For some rotations practised

Table 1. Crop rotations (second crops excluded).

Region	1st year	2nd year	3rd year	4th year	5th year	6th year
1 Begemdir/Simen	t'ef	t'ef	niger seed	t'ef	chickpea	t'ef
2 Begemdir/Simen	t'ef	finger millet	fallow or barley	pea	barley	pea
3 Gojam	barley	barley	barley	t'ef	fallow	fallow
4 Gojam	barley	t'ef	t'ef	niger seed	t'ef	linseed or niger seed
5 Gojam	t'ef	t'ef	niger seed	t'ef or finger millet	fallow	fallow
6 Shoa	chickpea or grasspea	t'ef	t'ef	t'ef	t'ef	t'ef
7 Shoa	legume	white t'ef	brown t'ef	brown t'ef	brown t'ef	brown t'ef
8 Shoa	legume	white t'ef	brown t'ef	brown t'ef	sorghum	pea or horse bean
9 Shoa	chickpea	white t'ef	brown t'ef	brown t'ef	fallow	white t'ef
10 Shoa	pea	wheat	t'ef	linseed	lentil	common bean
11 Shoa	t'ef	maize	niger seed	t'ef	maize	niger seed
12 Wellega	early maturing t'ef	late maturing t'ef	late maturing t'ef	finger millet	fallow or niger seed	fallow or white t'ef
13 Arussi	barley	pea or horse bean	linseed	fallow	etc.	
14 Arussi	barley	fallow	etc.			
15 Arussi	barley	wheat	pea or horse bean	linseed or fallow	fallow	etc.
16 Arussi	barley	wheat	linseed	fallow	fallow	etc.
17 Arussi	pea	t'ef	t'ef	wheat	horse bean or 2 × common bean	fallow
18 Gamu Gofa	wheat	wheat	barley	etc.		
19 Gamu Gofa	barley	fallow	pea	etc.		
20 Gamu Gofa	1. Galla potato 2. barley	wheat	fallow	etc.		
21 Gamu Gofa	Galla potato	fallow	barley	etc.		
22 Gamu Gofa	1. barley 2. barley	wheat	etc.			
23 Kefa	t'ef	t'ef	sorghum	taro	fallow	fallow

7th year	8th year	9th year	Remarks	Source
etc.			on black soils; no fallow	Simoons (1960)
fallow	?		on red soils; as a rule fallow after 6 years	Simoons (1960)
fallow	etc.		on red soils; fallow during 5th–7th year	Kuls (1963)
fallow	fallow	etc.	on dark, loose soils; fallow after 6 years	Kuls (1963)
etc.			on black soil	Kuls (1963)
t'ef	barley or wheat	sorghum, etc.	on black soil; Debre Zeit area	Huffnagel et al. (1961)
etc.?			on grey, sandy soil; no fallow? Debre Zeit area	Huffnagel et al. (1961)
barley	etc.?		on grey, sandy soil; no fallow? Debre Zeit area	Huffnagel et al. (1961)
brown t'ef	brown t'ef	sorghum or barley, etc.?	on grey, sandy soil; no fallow? Debre Zeit area	Huffnagel et al. (1961)
sorghum	barley	etc.?	on grey, sandy soil; no fallow? Debre Zeit area	Huffnagel et al. (1961)
fallow (6 years)			Bako region; fallow during 6 years	Ruthenberg (1971)
fallow	etc.		Region of Nejo in western Wellega	Taddesse Ebba (1968), pers. comm.
			Chilalo subprovince	Kline et al. (1969)
			Chilalo subprovince	Kline et al. (1969)
			Chilalo subprovince	Kline et al. (1969)
			Chilalo subprovince	Ryden (1972)
fallow	fallow	etc.	Riftvalley area	Kuls (1958)
			Dorse tribe in east Gamu Gofa	Straube (1963)
			Dorse tribe; fallow with green manure	Straube (1963)
			Dorse tribe	Straube (1963)
			Dorse tribe; fallow with green manure	Straube (1963)
			Dorse tribe; no fallow?	Straube (1963)
fallow	fallow	fallow, etc.	Jima area; in remote area; fallow as long as 20 years	Huffnagel et al. (1961)

in the Yerer-Kereyu region see Table 1: 6, 7, 8, 9 and 10.

In the *Bako area in west Shoa* sorghum, t'ef and niger seed are important crops (Murphy, 1959). For a typical rotation of this area see Table 1: 11. Ensat and Galla potato are also found here.

In *east Wellega* agricultural practices are, in general, similar to those in central and northern Ethiopia. Important crops are t'ef, barley, sorghum, maize, niger seed, most of them sown in June and July and harvested in December. As soon as the crops have been collected, the farmers start preparing the land for the next crop. Soil fertility is maintained by using a 'shifting-stable method': the farmers construct a rectangular enclosure on a plot of land which has to be fertilized. Cattle spends 10–15 nights there before it is shifted to another place. Where the cattle population is too low to produce enough dung to maintain a reasonable level of soil fertility, people resort to fallowing. A field may be left fallow for 5–6 years. In addition to shifting stables and fallowing, rotation of crops is carried out (Hailu Wolde Emmanuel, 1963a).

In the woyna daga of *west Wellega* coffee is grown. Farmers even burn the pasture lands to eliminate diseases and to further the propagation of good grasses. To avoid shortage of cereals during the rainy season, in many parts people cultivate sorghum and maize in the valleys: it is sown in February, irrigated, and harvested in July. In the uplands yams are grown: they are planted end January, and ripen in June (Hailu Wolde Emmanuel, 1963b).

A rotation for this region is listed in Table 1: 12.

3.3.1.2 The barley-hoe complex in connection with pastoralism of the Galla

Haberland (1963) showed that the ancient Galla were not merely cattle breeders, but also cultivated grain. Those who later on migrated to the north adopted ploughing from the Amhara; those moving to the west turned to an intensive form of hoe cultivation of the previous Western-Cushitic population. And those going to the Chercher Highlands took over the agricultural practices of the people living there at that time.

The ancient Galla agriculture in the highlands of Sidamo, Bale and Arussi was quite different from that of these groups. The hoe was used but manuring was unknown and the only crop was barley. Since the more recent expansion of the Amhara many Galla in the highlands of Arussi and Bale, as well as in parts of the Riftvalley like the lowland Arussi, gradually changed to the plough culture. Galla tribes who exclusively at present live in the lowlands as pastoralists are secondary off-shoots of a culture with a mixed economy. They originated from outpost-groups who became independent, and their practice of shifting pastures resulted in the division of many Ethiopian tribes into two strongly differentiated groups: the agriculturalists in the highlands and the pastoralists in the lowlands (Haberland, 1963).

Only some tribes kept to the old Galla type of agriculture. It is practised in particular among some Galla tribes in highland Sidamo, and possibly also in north-west Bale near the border of Sidamo. Some of these highland Galla keep their herds in the

lowlands during the rainy season, and in the highlands during the dry season. Shortage of pasture grounds, however, forces many to graze cattle near their settlements and on their fenced barley fields (Haberland, 1963).

At the beginning of the small rains, in March, preparation of fields start. As soon as a part of a field is ready, it will be sown with barley so that, later on, various stages of growth occur side by side. The last sowing is in June; the harvest is from November till January. In general, a plot is cultivated for three years and then left for an indefinite period, so that the cultivated fields occupy only a small part of the total area of pastures and bush vegetation (Haberland, 1963).

3.3.1.3 The grain-plough complex of Arussi and Bale

Under Amharic influence the people in Arussi and Bale turned to plough agriculture. Little is known of how and when this happened, but it is a fact that after the incorporation of Bale into the Ethiopian Empire in 1890, plough agriculture has considerably expanded there. On the highland plateau of Bale barley and wheat are the important crops. In the highlands of Arussi, especially in Chilalo subprovince, ploughing is now general practice, with barley the most important crop followed by wheat, linseed, pea and horse bean. In the woyna daga barley growing takes 5–6 months, in the daga usually 7–8 months. Unlike wheat, two harvests of barley are possible: the first between November and January, the second during June–July. Soil burning is practised south of Asella (Yilma Kebede, 1967).

All crops are grown on separate plots. Ploughing begins about a week after the onset of the rains (March–April), but fallow land is broken earlier (beginning in September or October). Three to four ploughing operations take place on fallow land before soil burning is begun in January–February. Land for linseed and pea is ploughed only once, for the other crops the second ploughing takes place in April–May, the third ploughing (in June) serves to prepare the seed-bed, and the fourth to cover the seed. In the area south of Asella, manure is added after soil burning, followed by a final ploughing before seeding. Some crop rotation is practised. Most frequently linseed precedes fallow and barley follows it (Kline et al., 1969). Some general rotations are listed in Table 1: 13, 14, 15 and 16. The last linseed crop is followed by a two year's (sometimes up to a five year's) fallow. Beans and t'ef are rarely included in the rotation (Ryden, 1972).

During the last decades the pastoral Arussi in the Riftvalley were forced to engage themselves in agriculture. They changed to plough cultivation with the same crops as in Shoa (especially cereals and pulses). Contrary to the Galla in Shoa, they use manure. Between Lake Shala and Lake Awasa their main crop is maize; sorghum, t'ef, wheat, barley, common bean, horse bean, pea, chickpea, lentil and grasspea are also cultivated, but linseed, niger seed and safflower are unimportant. Fields near the houses are well-manured and used for maize, often for several subsequent years, until the yields drop after which horse bean is planted followed again by maize. For the other crops a rotation is practised with 2–3 year's fallow during which the land is used as pasture.

A frequently applied rotation gives Table 1: 17. Field preparations start in February or March, after the beginning of the small rains. One or two weeks before sowing the fields are ploughed several times. Sorghum is sown in March, maize in April, t'ef, barley, wheat, pea and horse bean in July. Barley, horse bean and pea are harvested in October, maize in October–November, wheat in November, t'ef in December and sorghum in January. Chickpea is sown in September and reaped in December (Kuls, 1958).

3.3.1.4 The sorghum-plough complex of the highland of Hararge

The highlands, the sloping plateau to the south of Hararge and the valleys with sufficient drainage are extensively farmed. Characteristic is the dominant position of sorghum. In addition, a large number of other crops is grown. Several systems such as field cropping, gardening and tree and shrub cultivation are found there. Although the three systems are a part of the agriculture of nearly every village, field crops are by far the most important. Grain sorghum and the other field crops which are interplanted with it – or associated with it in the field rotation system – comprise the 'durra-complex' of this highland region (Brooke, 1958).

Irrigation is limited to the relatively few places where topography and drainage conditions permit the construction of channels or trenches which several times a year supply water from the main stream. Here tree or shrub crops are grown. Field crops, except sorghum, are rarely irrigated. On hillsides often rather crude drainage terraces are constructed, varying in width between 6 and 9 m, the vertical distance between the levels being only 30–60 cm. In the central section of the highlands bench terraces occur about 1.8 m wide, with walls built of rocks. Similar terraces are found on steep hillsides in the vicinity of Harar, but most of them are abandoned or planted with tree crops (Brooke, 1958). These highland terraces are everywhere mainly used for coffee and ch'at, and occasionally for vegetables. They are narrow and decrease in width with the steepness of the slope (Huffnagel et al., 1961).

Friable, well-drained, reddish and reddish-brown loams are the most widely distributed soil types. The region of Harar shows extreme erosion. Deep, V-shaped gullies have destroyed the moderate to steep hillsides. Where erosion has not ruined the land, it is cultivated rather extensively (Murphy, 1968).

Three main zones of cultivation can be distinguished: (a) the coffee zone (ca 1400–1700 m) in the southern valleys with coffee, banana, sweet potato *(Ipomoea batatas)*, ch'at and sugarcane; (b) the sorghum zone (ca 1600–2000 m) with sorghum as the dominant crop, and with coffee and ch'at on the borders of the valleys; and (c) the barley zone (ca 2000–2400 m) with barley, wheat, pea and horse bean (Schottenloher, 1939).

Preparation of the fields left fallow for several years involves breaking the turf with digging sticks during the dry season, 4–6 weeks before the small rains are due, and clods are overturned before ploughing. Moreover, for the seedbed preparations the fields are ploughed after the first rains, but nothing more is done until seeding.

The sorghum cultivars which require more time for maturing are sown first, followed during April by the principal sorghum type at about 1750 m altitude and during May in the lower areas. A much smaller area is seeded with fast maturing sorghum cultivars as late as June or July. Seeds are broadcast and covered by a second ploughing. Thinning is later on executed by ploughing. In December or January the sorghum is harvested. The stubble is left in the field, ploughed under during the preparation of the seedbed for the next planting, and finally collected and removed from the field for fuel or fodder. It is general practice to plant sorghum in the same field year after year, until the soil is exhausted. Eventually fields are left fallow for 2–3 years, in which time they revert into pasture, and are then planted with pea or another legume for one harvest. The length of the rotation cycle varies greatly. For the densely populated Harar region it averages probably 12–15 years (Brooke, 1958).

In general sorghum is found in mixture with maize and very frequently with common bean, sometimes with cowpea *(Vigna unguiculata)* or groundnut, as in the eastern part. Maize is the second important crop. As a field crop it is sown with sorghum in April and May and harvested between September and November. After 3–6 harvests of maize and sorghum fields may be rotated to one crop of barley or to some other small grain. At altitudes over 2200 m barley is important, but at lower elevations it occupies a relatively small acreage in the 'durra-complex', chiefly small fields under crop rotation and in plots planted late in the season after a partial failure of sorghum. Barley is sown from June to early August. As a rotation crop it is usually sown in June and harvested in October, about two months before the major sorghum harvest. Two harvests a year are not unusual. Except for the highest villages barley is never cultivated on the same field during the following year (Brooke, 1958). Fast maturing barley is grown from February to May and later before the planting of a leguminous crop. Moreover a kind of 'mist' barley cultivation is practised at ca 2700 m in the dry season from September to January (Schottenloher, 1939).

Common bean is the major leguminous crop in this complex. It is sown in April and by mid-July the pods mature and then the plants are pulled out. Immediately the field is reseeded again. The second crop is harvested usually late November. Pea is considered the best crop for sowing during the first year on land which has been fallow for some years. It is sown in July and harvested late in October. Chickpea and grasspea are grown in the dry season as second crop. Groundnut (runner type) is interplanted with maize and sorghum south-east of Harar; it is sown in April and harvested not before late November. This is done during two years followed by an equal period in which only maize and sorghum are grown (Brooke, 1958).

Sweet potato is the only tuber crop of any importance. It is cultivated on neatly constructed ridges. Cuttings are planted at the end of September and the beginning of October (Brooke, 1958).

Coffee is an important cash crop. Shrubs are planted on small terraces; they are unshaded, often irrigated, and receive great care. As a rule the trees remain unpruned until, after 15–20 years, they attain a considerable height; they are then cut back and a new cycle of growth begins (Huffnagel et al., 1961).

Interesting is the cultivation of ch'at. It is primarily used for its stimulating effect as a masticatory by chewing and usually swallowing the fresh leaves and twigs. Moderate use causes a feeling of well-being and strength, accompanied by thirst. Hararge is known as the most important production centre, especially the Dire Dawa–Harar region. It is cultivated mainly between ca 1800–2400 m, on well-drained hillsides which are often steep and bench-terraced (Hill, 1965).

3.3.1.5 The sorghum-hoe-terrace complex of the Konso cluster

In south and south-west Ethiopia sorghum is an important crop for many tribes dwelling on the fringes of the highlands (Jensen et al., 1959). Remarkable, however, is the group of tribes which practise agriculture on well-constructed terraces with stone-retaining walls. Most of them belong to the Burji-Geleba group, and for the Konso their agriculture will be outlined below.

Each terrace level has a small earthen ridge at the outside, and the level surface itself is divided by ridges perpendicularly to the outside ridge to facilitate the gradual penetration of water into the soil. On level terrain the same principal of division is applied. Pieces of land of 3 × 3 m are separated by ridges 10–20 cm high, which are also planted with crops. If possible, the terraces are irrigated. Water from small water courses is distributed through carefully constructed channels over the fields. In general, the irrigated fields on the terraces are several hundreds square meters large. Sometimes the irrigated fields are situated on terraces with stone-retaining walls as high as six meters (Kuls, 1958). Even the water that finds its way over the roads after rain is directed towards the fields through entries in the terrace walls (Nowack, 1954).

In the surroundings of the villages nearly all the land is permanently cultivated, the terraces are richly manured, and only a few pastures are found. The fields which are situated far away from the settlements are also terraced, but manuring is not practised. They take part in a rotation, in which a period of cultivation is followed by a usually longer period of rest. The greatest part of the available land is situated at some distance from the villages and is used as pasture. Field preparations start after the first rains, and are carried out with the hoe. In general, fields are worked only once before sowing. Manure is applied before sowing, but also frequently during the development of the crops. Weeding is done regularly, which gives the fields a garden-like impression (Kuls, 1958).

The number of food plants and wild edible plants used in Konso is extraordinary great. The most important cereal is sorghum. Above ca 1700 m it is superseded by wheat and barley. Nearly all fields with sorghum are mixed with finger millet. Nowadays maize has become an important crop (Hallpike, 1970). Pulses are very well represented in this area, including common bean, mung bean, cowpea, hyacinth bean, pigeon pea, chickpea, lentil, horse bean and pea. Many tuberous crops are cultivated such as taro, yam, sweet potato and also *Amorphophallus abyssinicus* and *Sauromatum nubicum*. Most striking is the 'cabbage tree' *(Moringa stenopetala)* of which the young leaves are eaten as a vegetable. Unexpected in view of the unfavourable ecol-

ogical conditions, coffee is found quite frequently. An important cash crop is cotton, two types of which are cultivated: *Gossypium herbaceum* var. *acerifolium* and *G. hirsutum* var. *punctatum* (Kuls, 1958).

In general, none of the crops is cultivated in separate fields. In the same field sorghum, sometimes even wheat and barley are grown together with beans, *Amorphophallus abyssinicus* and cotton. Consequently, no rotation or any regular change in land use is practised. In general the peripheral fields are cultivated for at least three successive years, i.e. as long as the cotton crop is profitable. The period of sowing and planting for nearly all crops is restricted to the weeks in which the 'spring' rains break through, generally in the first part of March. First the *Araceae* tubers are planted. Before the cereals and pulses in mixture are sown, cotton seeds are broadcast. Finally, all seeds are covered by soil. From May on the *Araceae* tubers are ready for harvest, but these are only used after a failure of the cereal crops. Mid-July the finger millet is harvested, and about the same time wheat and barley at the higher altitudes are ready for harvest. In August the beans follow, in mid-September the first sorghum crop is ripe and around December, depending on enough rainfall during the 'autumn' period, a second crop (ratoon) is possible. Because of the strict rainfall regime, with maxima during April–May and October–November (less than 900 mm annually), there are more critical periods in the labour calendar of the Konso than in that of the ensat farmers (Kuls, 1958).

3.3.2 The ensat-planting complex

The cultivation of ensat and its use as a staple food is found nearly exclusively under tribes in south-west Ethiopia, which speak either an East-Cushitic or a West-Cushitic language. The ensat-planting culture is located in the highland zone between ca 1600–3000 m. *Ensete ventricosum* is a common wild widespread species of Africa, and is known from Kenya and Uganda south to Mozambique and the Transvaal, and west to Zaire and Cameroun (Simmonds, 1958). In Ethiopia it is not common in the wild, although it certainly is subspontaneous in some places. Noteworthy is the fact, that the wild *Ensete ventricosum* occurs at a lower altitude than the present cultivation area of the plant in Ethiopia. This implies a modification in its ecological adaptation (Taye Bezuneh & Asrat Felleke, 1966). Until recently, the plant was botanically classed in the genus *Musa* L., although Bruce (1790) stressed the difference of the ensat with respect to the banana. For a general outline of the genus *Ensete* Horan., see Cheesman (1947).

Ensat is extensively grown above 2000 m in areas with an average temperature of 16 °–20 °C and an average annual rainfall of 1100–1500 mm. Although it can stand a certain period of drought, it grows best where rainfall is evenly distributed. The crop is propagated by suckers. To initiate shooting, a mature plant of 4–6 years old is dug out, and the pseudostem is severed from the corm in such a way that the lower part of the leaf sheaths (20–30 cm) remains linked with the corm. The central part of the pseudostem (the stem basis of the inflorescence) is completely cut out, and the hole

is filled with soil and dung. After burying the corm new suckers start to appear after 4–6 weeks. From such a corm 40–200 suckers may emerge if left in the same place for at least a year. Then the corm is dug out, the suckers are separated and transplanted in rows on a well-prepared plot, where they are left for 1–2 years. Under favourable conditions ensat plants are ready for transplanting into the permanent field three years after the emergence of the suckers from the parent plant corm. Soil, climate and altitude determine the development of the plants (Taye Bezuneh & Asrat Felleke, 1966). In general, the total period between the initiation of the suckers and the transplantation in the definite field varies between 3–9 years for each region and for each individual plant (Huffnagel et al., 1961).

After the ensat has been transplanted to its permanent place, maturation requires about three years at 1600–2000 m altitude, and more than four years at higher altitudes of 2500–3200 m (Taye Bezuneh & Asrat Felleke, 1966). Huffnagel et al. (1961) record three years at ca 1700 m, about five years at ca 2300 m, and six to nine years at ca 2800 m. As a rule plants are spaced ca 2–3 m square, which seems adequate for smaller types but too crowded for the larger. Ensat has a single flowering period (being monocarpic) and harvesting, either for food or fiber and propagation, takes place before the plant starts to flower. An average family, dependent on ensat as a major crop food, cultivates 200–400 plants, and the yearly consumption per person averages from 10 to 20 plants. Cultivation is carried out during November till January after the main rains. Manuring is practised continuously to maintain the productivity of the soil (except for, e.g., the Darassa). This is possible by the close connection with animal husbandry (Huffnagel et al.).

Interplanted crops include cabbage *(Brassica carinata)*, coffee and ch'at. In some areas coffee becomes the major cash crop after ensat has been grown from six to eight years. At ca 3000 m barley is a common crop along with ensat (Taye Bezuneh & Asrat Felleke, 1966).

The parts of ensat used as food vary from place to place. The pseudostem and corms are cut up and the pulp may be cooked when fresh or may be fermented in silos (Purseglove, 1972). It is also one of the chief fibre crops (Bezuneh, 1971). The main product, however, is a fermented starch of the pseudostem and the corm. The period of fermentation fluctuates between a few weeks and one or more years. Although slightly fermented starch is suitable for consumption, the longer the product has fermented, the more it is appreciated (Huffnagel et al., 1961).

It has been argued by Smeds that the ensat-planting cultivation is superior to the seed-farming of central and north Ethiopia as to maintaining the fertility of the soil, because manure is extensively used in the ensat areas. Foremost, however, is that the ensat-planting culture can support a denser population than seed-farming: the ensat regions are among the densest populated in the whole of Ethiopia, with a density of 175 habitants per square kilometer in some parts of Sidamo (Smeds, 1955). Simmonds (1958), referring to Smeds who estimated an average space per plant of 10 m^2, an average consumption of 12 plants per head per year, and who allowed an average 5-year cutting cycle with a ratio of 1 to 5 for the acreage of cultivated land to pasture,

concludes that 0.36 ha supports one human being (thus 278 men per square kilometer). This is intensive agriculture by any standards.

The extent to which ensat is supplemented by other crops varies from tribe to tribe. As far as staple food is concerned it is found among the Semitic speaking Gurage, and the East-Cushitic speaking Sidamo and related tribes. It is not the only staple food, but exists side by side to other crops, whether tuber crops or cereals, among the West-Cushitic speaking peoples in south-west Ethiopia, such as the Wollamo and the Kefa. In some cases, as among the Gimirra, ensat even has yielded its position as staple food to other tuber crops, whereas the East-Cushitic Galla in west Ethiopia do not cultivate ensat exclusively, but in addition to other crops.

3.3.2.1 Ensat as staple food

Ensat is the principal source of food for tribes who live either in the south-eastern part of the Ethiopian Highlands in Shoa, or in the Riftvalley and partly in the Eastern Highlands of Sidamo. Representative for this type of ensat cultivation are the Gurage and the Sidamo.

The *Gurage* live south of Addis Abeba, south of the Awash river. They mainly cultivate ensat, which provides the staple food of their diet, but they are also mixed cultivators. Ensat is extensively cultivated throughout the 'Sabat Bet' (the Seven Houses: tribes living in west and south Gurage district), except in the colder parts of the highlands where cereals and legumes are the principal crops. The Gurage practise a system of semi-permanent cultivation marked by an extensive use of manure and crop rotation that enables them to use the same plots indefinitely (Shack, 1966).

Space required for planting a new crop only becomes available after a mature ensat crop has been harvested. Hence, the agricultural season actually begins at harvest. Preparation of the soil, the setting of ensat and sowing of secondary crops take place in the dry season from September through March. Ensat fields vary in size, but the lay-out of fields in connection with the four stages of ensat growth is everywhere the same. Each section of land takes its name from the age of the plants grown there. Young sprouts are transplanted after some weeks close to the hut. They are never planted in the ensat field along with older, mature plants. By the end of one season 'suma' (a one-year-old ensat plant) is transplanted to the field and this is the start of the ensat cycle, i.e. the system of transplanting. All ensat that have reached one of the four respective stages of maturity in a certain season are transplanted. A period of eight years elapses between planting of 'suma' and harvest of the full grown ensat. Thus 'suma', planted in a certain season, proceeds together as one group through each successive stage of rotation, and is harvested in the same season, eight years later. Each 'suma' is transplanted to a manured planting hole from which a 'fanfa', having grown there for two years, has been transplanted to the second stage, 'takat'; the four year-old 'takat' advances to the next stage and is called 'matka'; transplanted, it becomes 'heba'. In the second year after transplanting 'heba' normally bears the

'false banana'. Gurage say that 'heba' should be harvested in the same season in which the 'false banana' appears (Shack, 1966).

On most Gurage plots a new ensat cycle is started each planting season, resulting in two overlapping cycles at any given time. Usually two ensat cycles contain a sufficient number of plants to maintain a more than satisfactory food supply. Consequently, the Gurage are capable to utilize a certain surplus of arable land for cash crop production. The average number of plants per year required for one adult is estimated about ten ensat plants. The final number is estimated on the basis of the family size, and thus regulated. By planting a definite number of 'suma' to provide for a concomitant number of matured plants, the harvest is rigorously controlled by the size of the farmer's family. By mid-December harvesting in most homesteads has been completed. The cultivation of cash crops is made possible by making the most intensive use of the available land. Spacing alloted between the ensat plants seldom exceeds 3–4 m, and is used for growing secondary and cash crops (Shack, 1966).

The *Sidamo* live south of Lake Awasa, partly in the Riftvalley, partly in the Eastern Highlands of Sidamo. The entire region is characterized by large ensat plantations, except the coffee plantation area around Dila, the cereal crops surrounding the Amhara settlements, and the pastures on the high plateau (Smeds, 1955). In Sidamo, and in other ensat regions as well, the numerous dispersed homesteads constitute physiognomically and functionally speaking a distinct complex. For the largest part the homestead[3] is planted with ensat, although other crops are cultivated too. Between ca 1700 m and 2000 m numerous coffee shrubs are grown together with small acreages of cabbage, taro, yam, maize, sorghum, beans, tobacco and condiments (Kuls, 1958).

In January or February corms of harvested ensat plants are buried, and after three months the newly formed suckers are transplanted. After about one year the young plants are finally planted in a definite field, which has been planted either with ensat before or at least for one year with maize and sorghum. Young ensat is never planted on new land or in places which have been in fallow for some time. In the final plot it will take 5–7 years before the ensat can be harvested. The different age classes are never mixed, but in the vicinity of the hut ensat of 2–3 years old is planted between older specimens to establish a permanent row of large individuals around the hut (Kuls, 1958).

The preparation of the fermented starch, 'kocho', takes mainly place in January and February and large provisions are established. If these are not sufficient till the next year or till the maize harvest in September, more ensat plants are harvested in July (Kuls, 1958).

Coffee seedlings are transplanted into the ensat plantation after one year. After 4–5 years the first harvest is reaped, and the coffee shrubs remain there as long as they

3. Kuls applied the term 'Hofland' (German).

do not die. Harvest time of coffee is from mid-December till the beginning of February (Kuls, 1958).

Already in February the first preparations are made for sowing maize and sorghum. Next to the ensat plantation a part of the homestead is mostly used for cultivation of maize, sorghum and beans for only two years, and afterwards the land either is left fallow or used for a new plantation of ensat. The cultivated plots of the homestead are irregularly bounded and in two successive years these boundaries are generally not identical. Within the homestead small acreages of wheat, barley, t'ef and pea are found, but the cultivation of cereals is very limited. The harvest of the cereals starts in September and goes on until, in the beginning of December, maize, t'ef, barley, wheat and sorghum are reaped. In spite of the application of cattle dung in that part of the homestead on which ensat is grown, this crop is not cultivated permanently on the same spot, but rotates. As a consequence also the homestead undergoes a periodical shifting. Only ensat, coffee and cabbage are manured (Kuls, 1958).

Outside the boundaries of the homestead the Sidamo regularly use land for a kind of shifting cultivation. Here the bulk of the cereals is grown. In January pieces of forest are burnt and cleared, and at the end of February maize, sorghum and t'ef are sown. Wheat and barley, however, are seldom sown on these plots. Altogether such plots are in use for a period of 2–3 years, and afterwards they may revert to forest again. Sometimes young ensat plantations are started (Kuls, 1958).

Different zones of cultivation within the ensat area can be distinguished. Between ca 1800–2000 m coffee is the most important cash crop. In this coffee zone maize is an important cereal. At about 2000 m maize, sorghum and coffee diminish and wheat, barley, pea and horse bean appear. In this wheat-pulse zone, which extends till ca 2500 m, the cultivation of cereals and pulses is carried out in a not-fixed rotation of crops without the application of manure, and implements used are mainly the hoe and the digging stick. Typical for this zone is the presence of nurseries for ensat. On small bamboo-fenced plots a cereal is grown the first year followed by ensat suckers in the second year, which are manured. Finally, the next year a cereal or a pulse follows, and after the harvest the plot is used as pasture as before (Kuls, 1958).

The upper ensat zone, the barley zone, starts at ca 2400–2500 m and continues till 3000 m. Characteristic are the bamboo fences and huts. Only barley and cabbage together with ensat are important crops. Close to the hut relative large plantings of cabbage are found next to the ensat plantation in which the exit of the hut finds its way. The cabbage leaves are an important market product. They are grown on the same place for several years and the leaves are cut when needed. Barley is cultivated in the homestead as well as on plots situated further away in the midst of pastures. The latter fields are exclusively used during several successive years for barley cultivation. Since seeding of barley is carried out over a longer period of time, all stages of growth and maturity are found within the same field. Harvest extends from January to early March. Above 3000 m all cultivation disappears and these high altitude regions are only used as temporary pastures (Kuls, 1958).

3.3.2.2 Ensat as co-staple, with cereals and tuber crops

Here ensat has lost its dominant position and shares its importance as food crop with cereals and tuber crops. This type of ensat cultivation is found in north-west Sidamo (Wollamo), Gamu Gofa and Kefa. Therefore the agriculture of the Wollamo, the tribes of east Gamu Gofa, the Kefa and the tribes of west Gamu Gofa is treated next.

The *Wollamo* live in north-west Sidamo north of Lake Abaya. In their homestead the quantitative distribution of the crops is not the same as in Sidamo, due to a different proportion between ensat and the other crops as well as of other methods of cultivation. Especially in the eastern part of this region a nearly fixed arrangement of crops around the homestead is observed. On both sides of the entrance cabbage, tobacco, chillies and some spices are grown, behind the hut a half circle of coffee shrubs is present, and behind these a relatively small ensat plantation. Further on fields are situated with a mixture of maize, sorghum, beans and cabbage, and finally the most remote parts are used for unmixed fields with t'ef, wheat, barley, pulses and various tuber crops. Application of manure is not restricted to ensat and the immediate surroundings of the hut as in Sidamo, but is applied on other parts of the homestead as well, though not all crops are fertilized and in general manuring diminishes with the distance to the hut. On fields near the fringes of the homestead crops are rotated in certain successions in which a fallow is irregularly included (Kuls, 1958).

The ensat plantations occupy not more than one fifth of the total area cultivated. The cultivation and use of ensat itself do not differ basically from those of Sidamo; only the design of provisions is much less developed. New suckers are obtained by slicing a suitable corm into pieces and burying these. Most ensat types are harvestable after a growth period of four years (Kuls, 1958).

In February the Wollamo start planting sweet potato on land ploughed first and tilled with the hoe, without application of manure. The cultivar in use produces white, round tubers as opposed to the small dark tubers of a second cultivar planted in June. In March and April a mixture of maize, sorghum and beans is sown on fields ploughed at least twice or hoed. Immediately after sowing the field is ploughed again. Without manure it is possible to grow a mixture of crops for several years in succession at the same place. Afterwards, either the land is left fallow for a year, or other crops are grown, preferably sweet potato. Successively, after ploughing and sowing, the fields with wheat, pulses and barley at the end of May or the beginning of June, and the second type of sweet potato are planted. In the same period the sweet potato planted in February is ready for harvest. Sweet potatoes are not planted in ridges. All fields are weeded at least once during the development of the crops, which task has to be finished before the seeding of t'ef in July (Kuls, 1958).

Special attention is given to the cultivation of taro and the Galla potato. The taro fields are ploughed or hoed and planted in November; during the next twelve months in which the crop develops, regular cultivation with the hoe is performed. The Galla potato accompanies ensat till its upper limit of cultivation and is also found in east

Gamu Gofa. Fields for the Galla potato are prepared with the hoe; broad furrows are constructed in which plant holes are made. Each plant hole is manured and finally 3–4 pieces of a sliced tuber are planted per hole. After ca one month, in the middle of May, the young plants are earthed up and this is repeated several times so that finally the plants stand on ridges 10–20 cm high. After the harvest, which begins in September, planting material for next year's crop is kept in the field till December; afterwards the tubers are wrapped in ensat leaves and grass and buried in the ensat plantation till April next year (Kuls, 1958).

The harvest of the cereal crop starts in November with barley and ends in the beginning of January with maize and sorghum. Also yams *(Dioscorea abyssinica, D. bulbifera)* are grown, as well as potato. Owing to the cultivation of various tuber crops the Wollamo have some of these at their disposal the whole year round. Compared with the Sidamo this is a much richer menu as far as tuber crops are concerned (Kuls, 1958).

Each altitudinal zone has its particular crops but, of course, the limits of cultivation for the individual crops are basically the same for the different tribal regions. Between ca 1400–1500 m the first settlements of Wollamo appear with sorghum, maize, bean, yam, taro, tobacco and cotton as important crops. Around the huts dense stands of sorghum and maize are present. They are well-manured but already at 10–20 m distance from the huts manuring diminishes sharply. Close to the homestead various yams grow on plots of a few square meters. Further away crops are grown in rotation and a large part of the land is under grass. This lower cereal zone is rather extensive, plots are often terraced, which is not the case in the corresponding zone of the Sidamo and related tribes (Kuls, 1958).

With the appearance of ensat at ca 1500–1800 m larger parts of the homestead are available for other crops. Till ca 2000–2100 m ensat is accompanied by sorghum, maize, taro, sweet potato and yam. There exists no zone of intensive coffee cultivation either in Wollamo nor in the adjacent southern region. Above ca 2000–2100 m Galla potato and potato become more significant, and from ca 2400 m barley is the only cereal. In the higher parts potatoes have superseded cabbage and their cultivation is simple: fields are ploughed or hoed every 3–4 months. Tubers brought to the surface are collected, those left behind in the soil are sufficient for a new crop. After some years the harvest is so low, that fields may left fallow or used for barley. In the highest zone of the ensat cultivation area this barley is grown without terraces. As a protection against erosion, sloping furrows are constructed in the fields with the digging stick to make the water run off quickly. Below ca 2500 m two barley harvests a year are possible. The first crop is sown in March, the second in July or the beginning of August and quite often on the same piece of land. In both cases manure is applied. Above ca 2500 m only one crop of barley is possible; it is sown in July or August at the height of the big rains (Kuls, 1958).

The *east Gamu Gofa tribes* live in the highland region immediately west of the Riftvalley. Also here ensat is not the only important food crop: the Galla potato is a

common tuber crop and it is, next to barley and ensat, a most important food crop. It is not grown in furrows, as in Wollamo, but on a kind of beds, on land having been fallow for one or more years. The ditches between the beds reach 50–70 cm deep and at mutual distances of 2–3 m. They irregularly divide the field and collect water during the rainy season. The cultivation of Galla potato (during June to October) is never repeated on the same field in the next year. For the cultivation of barley after the Galla potato, the field has to be levelled (Kuls, 1958).

Everywhere in the lake region between ca 2000–3000 m the tuber of a wild growing *Arisaema* has some importance for the poorer people. The tribes of east Gamu Gofa seem to eat this tuber, and it is not only collected wild but also grown between ensat plants or in barley fields. Sometimes fields exclusively planted with this *Arisaema* are found (Kuls, 1958). According to Jackson et al. (1969) it is *A. schimperianum* and is unique for the highland of south-west Ethiopia.

A coffee zone within the ensat region is absent, as in Wollamo (Kuls, 1958).

The extensive cultivation of barley in the highest zone of ensat cultivation is largely a field-grass rotation. Plots are preferably located on sloping ground and earthen terraces dominate the landscape of this zone. Fields are fixed and worked with the hoe, but the use of the plough is not unknown (Straube, 1963). The terrace surface slopes somewhat in the direction of the outer side and consequently the rainwater is carried off quickly. Often small furrows at the foot of each terrace are constructed through which the water runs off into larger drainage canals. To consolidate these terraces strips of grass are saved during the construction. Some tribes construct terraced fields of 10–20 m, sometimes up to 50 m long, with walls as high as 1–2 m (Kuls, 1958).

The dominant position of barley in the highest ensat zone is demonstrated by the fact that within the homestead barley grows on very well-manured plots. As in Sidamo, the homesteads and the ensat plantations shift after some time, not because of the poor development of the ensat, but because the land around the homestead is worked and manured so intensively during several years, that it becomes well-suited to cultivate barley. Up to ca 2500 m two barley crops are possible: sowing is in March and in July or in the beginning of August, mostly on the same plot and harvested in July and December respectively. In the barley zone it is sown in July or August (Kuls, 1958).

Typical for the higher regions of this ensat cultivation area is a small type of ensat, the corms of which are sliced and boiled. Plants are cut when one meter high. Probably this way of consumption is a result of the longer growth period of the plant (Kuls, 1958).

At the upper limit of cultivation, between 3000 and 3100 m, there is an abrupt change from agriculture to pastures. Only a few settlements are found which are surrounded by cabbage plots and barley fields, as in Sidamo (Kuls, 1958).

For some rotations in this region see Table 1: 18, 19, 20, 21 and 22.

The *Kefa* live in Kefa province south of the Gojeb river in a high rainfall area with forest vegetation. Here ensat is grown around the houses and is one of the staple

foods. Its cultivation is highly developed. A great variety of crops is grown in addition to ensat like maize, sorghum, wheat, barley, t'ef, various beans, pea, Galla potato, taro and yam. Farms are situated on isolated places in the forest and its inhabitants cultivate their plants and crops in gardens as well as on fields. In general, fields or plots are used for cultivation during 4–5 years, then left fallow for one year and are planted with another crop again. No regular rotation between cereals and other crops is practised. The fallow land is in use as pasture and slowly reverts to forest, which may again be burnt to start cultivation. According to the description of the land-use pattern given by Bieber (1923), the Kefa only partly follow the system of shifting cultivation. The application of manure is unknown, but cattle are allowed to graze the hoed or ploughed land. In December, grass and crop residues are burnt and the ashes are spread over the fields. The planting season generally coincides with the small rains between March and June (Bieber, 1923).

The *west Gamu Gofa tribes* live in the higher parts of west Gamu Gofa, above ca 1800 m, like the Ari tribes. Their culture as well as their economy is of an utmost simplicity (Jensen et al., 1959). Among the food crops ensat occupies an important place, whereas sorghum is the dominant field crop. Ensat plants reach a height of 4–5 m in three years. Already in this stage harvest starts. Among the Ari tribes the process of fermenting in a pit is rather primitive and by no means reaches the standard of the highly developed and complicated fermenting procedure of the ensat-growing people of the lake region treated above. Sorghum is prominent, but finger millet, barley and maize are also grown (Pauli, in: Jensen et al., 1959).

At the end of the dry season field preparations start with burning of fields and pastures followed by breaking up the soil with long digging sticks and the lumps are chopped with a hoe to prepare the soil for seeding and planting. Occasionally the plough is used (Pauli, in: Jensen et al., 1959).

Cereals are grown for seven years in the same field which afterwards is left fallow for only two years. Maize is sown in February; at high altitude it takes eight months before it can be harvested. Sorghum is probably sown later, the different types at different times. Only the panicles of sorghum are harvested and the rest is burnt during the clearing of the field. The barley crop, however, is reaped by pulling out the entire plant. Reference is made to three types of beans: horse bean, a bean called 'zati' with cordate leaves maturing in 6–8 weeks, and a perennial bush bean (Pauli, in: Jensen et al., 1959).

North of the Ari, tribes live which perform a more intensified form of agriculture. Here, next to ensat, yam, sorghum and maize are important food crops. Ensat is either skilfully fermented or cooked. It is one of the most densely populated areas of Ethiopia with about 200 people per square kilometer (Haberland, in: Jensen et al., 1959).

3.3.2.3 Ensat not as co-staple, with tuber crops dominant and cereals of secondary importance

Ensat lost its position as a co-staple and other tuber crops have become prominent to the neglect of cereals. This type of ensat cultivation is found in Kefa, e.g. under the Gimirra tribes.

Most *Gimirra tribes* are living in west Kefa between the Gilo and Akobo rivers. The whole area is covered with dense rainforest which has its lower limit at about 1300 m. The culture of the Gimirra people is pre-Cushitic and probably older than the Nilotic culture. It represents a remnant of root cultivators. Negritic elements dominate, as is the case with the Ari tribes in west Gamu Gofa. Agriculture shows pronounced primitive elements. Intensive forms of agriculture like terracing, manuring, irrigation, rotation of crops are unknown or only very weekly developed. Extensive shifting cultivation is applied, and the main crops are yam, taro and ensat. Ensat as food is less important than yam and taro. Maize, sorghum and t'ef play a minor role and generally cereals are only of secondary importance. Cattle raising is not economically important either (Straube, 1963).

The Gimirra tribes are not familiar with the complicated and specialized processes of food preparation of ensat. The corms are cut into pieces and cooked as a vegetable. Yams are the most valuable crop and several types are distinguished. As a rule, yam is planted in rows in fields, whereas taro is grown on fields close to the huts. Ensat plants are irregularly planted in the gardens, mixed with coffee and other crops; closed plantations are hardly present. Young plants are fertilized with domestic refuse. The collected cattle dung is spread only over fields, which are situated on the spot of a recently abandoned homestead. Here, ensat, yam, and taro are planted. Ensat plants are harvested when they are three years old, since they start flowering the next year at this altitude (Straube, 1963).

On recently cleared land maize is the first crop to be sown; often grain amaranth *(Amaranthus caudatus)* is found growing mixed with it.

Sorghum is sown in fields which are not cleared. Directly after sowing weeds are cut and dried, and after one month they are carried off. Between two cultivation cycles the fields are left fallow during one to two years, though sometimes as long as six years. By that time the fields are covered by an impenetrable vegetation and have to be burnt again. Fields with a short fallow period are cultivated in the following sequence: maize-sorghum-tuber crops. Maize and sorghum are sown in February and harvested in August-September. Other sorghum types are sown later and consequently harvested in December–February. Yams are planted in December and harvested in June–August. Taro is planted in December and can be used after ten months; in general, however, it occupies the fields up to five years. Coffee is prepared in a very ancient way by roasting the leaves over a fire and pounding them; finally it yields a tea-like infusion (Straube, 1963).

3.3.2.4 Ensat not as co-staple, with cereals dominant and tuber crops of secondary importance

Ensat is cultivated in addition to other crops, of which cereals dominate. This type of ensat cultivation is found among the Galla in Wellega, Illubabor and Kefa. Here the Galla of Kefa will be treated.

The *Galla of Kefa* live north of the Gojeb river. As a rule they do not exclusively cultivate ensat but in addition to other crops such as maize and t'ef. It seems that the Galla were attracted by ensat as a security crop when other crops fail. In fact, the area they occupy is not always well-suited for cultivation of ensat as it lies relatively lower than the land of the important ensat growers. The main area of Galla ensat growing is found in the former Gibbe states north of the Gojeb (Stanley, 1966).

For the Jima Galla the base of economic life is mixed agriculture and the principal implement is the plough. Climate and wealth of crops in Jima make it possible for the farmers to have different crops growing throughout the whole year. Cereals are of paramount importance, t'ef being the foremost. Maize also plays an important role, especially as it is the only cereal harvested and eaten during the rainy season. Sorghum is an other important crop. Finger millet, wheat and barley occur less. Other field crops include lentil, chickpea and taro. Among the main garden crops are ensat, yam, Galla potato, sweet potato, several types of beans, and a few leafy vegetables. Ensat is not important, but it does fulfill a need during the rainy season and in other periods when few cereals are available. The basic cash crop is coffee; since most coffee is grown in the shade, it is planted under trees around houses and fields. Irrigation and terracing, although practised, are not applied on any large scale (Lewis, 1965).

For a possible rotation in this area see Table 1: 23.

3.3.3 Shifting cultivation

Only scarce information is available on the occurrence of shifting cultivation in Ethiopia. It is reported for some tribes living on the western and south-western fringes of the Ethiopian Highlands, like the Cushitic-speaking Kefa and Gimirra (Bieber, 1923; Straube, 1963). In the lowlands of west Ethiopia it is practised by tribes speaking Negro languages, like the Gumuz and other peoples (Cerulli, 1956; Hailu Wolde Emmanuel, 1963b; Kuls, 1962; Simoons, 1960). Finally it is reported to occur in some parts of Sidamo (Kuls, 1958). Here the Gumuz wil be treated.

The *Gumuz tribe* mainly dwells in the k'olla region of Begemdir and Gojam. Sorghum is the main food crop, cotton a prominent cash crop. Other food crops are maize, finger millet, sesame, groundnut, yam and ginger (Kuls, 1962; Simoons, 1960).

Important implements are the planting stick and the hoe. Irregularly shaped plots mostly are situated far from the settlements and are cultivated only for 1–2 years.

Afterwards they are left and revert into woodland. The choice of a piece of land for cultivation which already has been used before depends on the presence of certain indicator plants. During the dry period of January and February pieces of land are cleared, and in March they are set on fire. When the rains come through crops are sown (Kuls, 1962).

The Gumuz distinguish different types of fields depending on the crops.

1. Fields with sorghum and finger millet Between the end of March and May these cereals are sown in a mixture. Some time afterwards a kind of bean ('hopa'), pumpkin, cabbage, and other crops are sown in between. The cereals are harvested in December. Next year the field is used again and a ratoon is harvested from sorghum that sprouts a second time from first season's shoots; besides, new sorghum is sown together with beans and pumpkin. Finger millet, however, is not sown for a second time.

2. Fields with sesame After clearing and burning the fields are sown in June and July with sesame only, and harvested in December. Next year the cultivation is not repeated.

3. Fields with cotton The crop is sown in June and the harvest starts at the end of December–January after the sorghum crop and continues till May. Afterwards such a cotton field is used for a second time. Sometimes sesame and sorghum are sown in between the cotton crop. Cotton is an important product on the highland markets of Begemdir and Gojam.

4. Fields with ginger These are found on the steep slopes of narrow valleys. Before burning only the undergrowth is cleared. Ginger is an important item on the highland markets.

5. Garden-like fields These rather small fenced fields lie close to the huts on land which has been fertilized with manure of small domestic animals. At night cattle is kept in movable enclosures that shift every 4–7 days. At the end of the dry season yam is planted on these manured pieces of land, followed by the sowing of other crops in March and April (Kuls, 1962).

3.3.4 The pastoral complex

Agriculturalists in Ethiopia belong to three main systems of farming. There are the seed farmers, the ensat-planting farmers and the pastoralists (Simmonds, 1958). These three systems, which are the result of climatic and ethnic factors, are not always clear-cut, neither in operation or in locality; nor are they static. All depend on the raising of livestock. To a greater or lesser extent seasonal migrations of livestock are common in all three systems. In the seed-farming areas, mainly in regions over ca 1600 m, cattle are kept chiefly for ploughing and breeders are needed to produce ploughing team replacements. Other livestock is limited because of the competition of arable land with the available pastures. In the ensat-planting areas domestic animals are very important in the economy, as dung is indispensable for the cultivation of ensat and other crops. As a rule, the ensat growing areas are situated at the higher altitudes from 1600 m to 3000 m and in those parts where rainfall is substantial and

well-distributed. Both the population and cattle densities are high (Huffnagel et al., 1961).

The pastoral areas are usually, though not always, in the lower and drier parts of the country. Here large herds of cattle, sheep and goats are kept, as well as camels in the driest areas. The main areas of concentration are in the north, Hararge, the Danakil Plains, the southern part of Sidamo, and the areas north of Lake Rudolph. The grazing system of the pastoralists varies. Most pastoralists are nomadic, or semi-nomadic. Past invasions and migrations have brought some of them into areas where rainfall is adequate for arable farming, but the old traditions remain. In Ethiopia areas still exist which, though suitable for intensive farming, lack crops and ploughed land because the people carry on an extensive system of livestock raising (Huffnagel et al., 1961).

This situation, however, is not static. Administrative changes have often caused the land in these pastoral areas to be allotted to people who are arable farmers by tradition and who brought their plough culture with them. The colonization of such formerly pastoral lands proceeded quickly after the incorporation of the south into the Ethiopian Empire. Here the plough is not only used by immigrants from other parts of the country, but also by the local people (e.g. the Arussi). These pastoral areas are mainly inhabited by the Galla (such as the Borana, the Arussi), the Somali and the Danakil tribes in the south and east, and several tribes in the north (Huffnagel et al., 1961).

The Galla and the Somali will be briefly treated below.

The *Galla* had an economy in which cattle-rearing and a very archaic form of grain cultivation were combined (see 3.3.1.2). This was given up when they established themselves permanently in the lowlands like the Borana, or adopted plough agriculture like the Arussi (see 3.3.1.3).

The grazing system of the Galla in south Ethiopia and most other south-Ethiopian tribes is characterized by the word 'fora' (place for cattle). It means that the majority of the cattle dwells on pastures far away from the semi-permanent settlements. For tribes practising the cultivation of crops and with little cattle the division between agriculturalists and cattle herders is sharp. For some Galla this division is not so marked, in particular for the tribes living only in the highlands. For other Galla tribes, however, which dwell both in the highlands and in the lowlands, the system of grazing resembles that of other south-Ethiopian peoples: the cattle dwell either in the lowlands, or they developed a kind of transhumance. This means that part of the tribe moves with its cattle from the highlands to the lowlands during the rainy season, and returns to the high ground after the end of the rains. Sometimes cattle is also kept during the dry season in the lowlands (Haberland, 1963).

Even the Borana of south Sidamo, who exclusively live in the lower situated regions and have completely abandoned the cultivation of crops, still apply the system of 'fora'. Around their semi-permanent villages, close to the wells, only a part of the herds is found. The young men dwell on 'fora' with most of the cattle (Haber-

land, 1963).

In the lowlands of the Riftvalley as well as in the highlands of Arussi and Bale, the Arussi tribes are engaged in plough agriculture (see 3.3.1.3). To which extent this plough culture has penetrated eastwards is not known. Prior to 1900 the Arussi distinguished three main zones with different regulations for settlement and transhumance. During the driest months of the year the herds of cattle stayed in the upper part of the highlands (ca 2300 m and higher). At the beginning of the small rains most cattle was transferred to lower parts of the highlands (ca 1800–2300 m). When after about two months the big rains came through, again cattle changed pastures and moved down into the lowlands, where they lived for several months till the beginning of the dry season. Then people and cattle moved back to the high grounds. Nowadays the migrations of cattle between the different altitudinal pastoral zones are severely restricted, because the acreage of pasture is limited by the rapid expanding cultivation of crops, both in the lowlands and on higher grounds in western Arussi (Haberland, 1963).

Most *Somali* dwell in the south-eastern part of Hararge and the southern part of Bale. They are largely semi-nomadic people. They camp on seasonal grasslands to feed their herds of camels, sheep and goats, and then move on in search of new water and pasture, irrespective of international boundaries (Lipsky, 1962).

Among the few plants of economic importance indigenous to the Horn of Africa the wild growing Yeheb-nut *(Cordeauxia edulis)* is of particular interest. Its occurrence in Ethiopia is limited to areas in the extreme south-east of Hararge. Although the protein content of the seeds is lower than that of the current legumes, it has the advantage of being comparatively rich in fat and in sugar. However, the shrub has disappeared from many regions, partly due to the continued overall deterioration of the vegetation by overgrazing, partly to the thoughtless exploitation of the shrubs for their nuts (Bally, 1966).

4 Plant taxonomy

4.1 Taxonomy: 'an unending synthesis'

Taxonomy is the practical result of the basic human urge to make some kind of a comprehensible arrangement of the elements of the environment. No aspect of biology is more deeply intertwined in history, economy, literature, aesthetics and folklore than classification, with its overt concern for the variety of organisms in the world (Constance, 1964).

Plant taxonomy aims at the identification of taxa, and the arrangement of these into a scheme of classification that shows their relation. It is the science of affinities, and its object is to invent a scheme which mirrors not only the phylogenetic relations that unite different groups of organisms, but also the phylogenetic similarities at each taxonomic level (Löwe, 1964). Taxonomy is one of the most important botanical disciplines because its conclusions are fundamental to other approaches in general and to the study of evolution in particular (Löwe, 1962).

The species has long been considered the elementary unit of all taxonomic work. This view has its origin in earliest civilizations and the species was the category on which the Theory of Special Creation was founded. According to the theory of evolutionary development, no single category is a basic phyletic unit, for the category of 'species' is no more fundamental to a phylogenetic scheme than is any other category, and all categories must be accepted as 'a phase in evolution'. But despite this, the species is the category on which the binomial system of nomenclature has been established (Lawrence, 1966).

The classical botanists defined the species in morphological terms, since no other criteria were available. The 'morphological' or 'taxonomic' species concept was well-defined in a more sophisticated way by Du Rietz (1930), as 'the smallest natural populations permanently separated from each other by a distinct discontinuity in the series of biotypes'. This definition lays emphasis on populations rather than single dried specimens in a herbarium; it brings the concept of the biotype, which is one or more individuals of very similar genotype; and it stresses discontinuity between species, whether of a morphological or any other type. Contrarily, the 'biological' species concept, advanced by biosystematists, geneticists and cytologists, stresses reproductive isolation, either actual or potential, as the method of determining species boundaries (Hawkes, 1970). The simplest and clearest definition was proposed by Mayr (1940) who regarded the species as 'groups of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups'. As

Löwe (1964) indicates, the avoidance of all reference to morphological characteristics is significant. The breeding system prevailing in any group of plants is of great taxonomic importance, for it governs above all factors the pattern of group-variation (Heslop-Harrison, 1967).

Since Linnaeus did not give a sharp definition of his species concept, other botanists soon ventured to do this for obtaining a distinct guide to determine this category. The definition most closely related to the works of Linnaeus was phrased by De Candolle (1813), who regarded the species as 'la collection de tous les individus qui se ressemblent plus entr'eux qu'ils ne ressemblent à d'autres; qui peuvent, par une fécondation réciproque, produire des individus fertiles; et qui se reproduisent par la génération, de telle sorte qu'on peut par analogie les supposer tous sortis originairement d'un seul individu' (as cited by Löwe, 1962).

Botanists studying the variation within the Linnaean concept of species soon discovered that morphological characteristics alone are not always an easy way of distinguishing a species. It also became evident, as mentioned by Löwe (1962), that the limits between species are not always sharp and some species include considerable morphological variations that may also be geographically or ecologically distinct. Even Linnaeus knew this and included such variations in his concept of variety. When Ehrhart (1788) realized that such variations within a species actually may be at different levels, he proposed the category of 'subspecies' to distinguish a major geographic taxon that is composed of varieties or minor geographic taxa (Löwe, 1962). Although this was a reasonable solution that did not require any change in the Linnaean standard, some students of these variations have preferred to deviate from the classical approach and to use the species category not only for the Linnaean species but also for these geographic variants. The tendency to use the species category for small splits from the Linnaean species, though maintaining it also in the classical sense for other taxa, was, according to Löwe, strongly advocated by Kerner (1866). Instead of accepting Ehrhart's proposal he preferred to give each of such variations a species name, provided that they could be distinguished morphologically, described, and then again recognized. Many post-Linnaean taxonomists tended to be deceived by the conspicuous morphological and ecological differences between some taxa that have not yet developed the slightest degree of reproductive isolation (Löwe, 1962).

Lamprecht (1949) traced the developments and changes in species concepts, classifying them in the following periods of taxonomic research: (1) description without taxonomic systems (ca 3000 B.C.- ca A.D. 1550), (2) development of artificial and natural systems (ca 1550 - ca 1860), (3) systems in the light of evolution (since 1860), (4) detection of speciation by addition of genomes (ca 1900 - ca 1960?), and (5) detection of the genic basis of the species barrier (since 1950). Obviously most taxonomic research has been carried out in the third period, and the biosystematist is now working in the last two periods (Lawrence, 1966).

One of the major trends in taxonomy during the past half century has been the attempt to reduce the scope for the operation of 'opinion' or 'intuition' in classification by substituting it by experiments, statistics, or machinery (Constance, 1964).

Biosystematics is a phase in botanical and zoological research that endeavours, by studying populations, to delimit the natural biotic units, and to classify them objectively as taxa of different rank. This necessitates the use of data from other disciplines such as ecology, genetics, cytology, morphology, phytogeography, and physiology, particularly as observed from plants grown under both artificial and natural conditions. In this approach emphasis is placed on cytogenetics and cytotaxonomy supplemented by the classical approaches of morphology, ecology and plant geography (Lawrence, 1966). According to Lawrence from the general definition of biosystematics it becomes clear, that it has the same goal as has modern taxonomy, and that it differs from it only in emphasis and techniques, which means that, botanically, both are methodological variants of one discipline: taxonomy.

According to Löwe (1964), the system created by the classical method to a certain degree mirrors the phylogenetic relations that unite different groups of organisms, as well as the phylogenetic similarities at each taxonomic level, but its failure to define the basic categories is inherent to its lack of appreciation for fundamental evolutionary processes. But, what else could correlation of numerous characters mean but a common genetic and evolutionary background (Constance, 1964)? In contrast to the rather artificial species of the ancient typologists and some more recent morphologists, the 'biological' species (or 'real species' as Löwe (1964) puts it) is a natural and unarbitrary unit of a genetically closed population system that has lost the ability to interbreed with other such systems. It usually coincides with the Linnaean species selected with the reproductive gap. The genetic barrier is due to cytological differences, so it can be detected and defined with the aid of cytological methods. Following Löwe (1964), the 'biological' species concept usually permits the delimitation of a sounder and more meaningful 'taxonomic' species than does the often random aggregation of individuals based on 'the groping concepts of the classical avoidance of such a singular definition'. Its general acceptance would soon change 'the ancient art of classification into the modern science of critical taxonomy'. But as Löwe wisely added: 'the method of approach is itself largely ruled by the kind of answer one anticipates'.

In classifying infraspecific taxa, it must be realized that each species is a reproductive community, interacting as an ecological unit with other such communities. Each consists of populations, each of which is an expression of an integrated gene pool. Following Löwe (1964) their variations are due to subspeciation processes of gene mutation, recombination, and natural selection, but without participation of the speciation processes of reproductive isolation. Evolution below the species level is characterized by a continuum of variations and not by a succession of distinct types, except when affected by some kind of subsequent geographic or similar isolation. Infraspecific variations may be very distinct due to isolation (geographic or otherwise); since they lack an internal barrier to gene exchange they are, however, temporary advances that at any time can be reversed into the general gene pool of the main population of the species (Löwe, 1964).

A definition of species involving the concept of interbreeding between its popu-

lations and, on the other hand, sterility with respect to populations of another species is at first glance simple and satisfying, but presents many practical difficulties (Hawkes, 1970). That two species do not exchange genes at present does not mean, that they never did in the past or can not do so in the future. Even though in nature no gene exchange may take place because the involved species are geographically or ecologically separated, they may be crossable under experimental conditions. In practice it is extremely difficult to decide on the exact point to draw the dividing line. After all, species names are expedient to indicate some kind of natural groupings (Hawkes, 1970).

Within a seemingly perfectly 'respectable' species chromosomal or other genetic barriers to gene exchange often separate groups of populations. In the 'biological' species concept, following Hawkes, each of these groups which is separated from the others by sterility barriers should be considered a distinct species, even though it is possible solely by breeding experiments to distinguish them. Since a very small part of the world's plants have been studied experimentally in this way, this would mean that it is not yet possible to give species names to any but a small fraction of the plants, and the writers of Floras and those who work in the field of ecology, plant geography, economic botany and allied fields unconnected with breeding and genetics would lack names for the plants they work with (Hawkes, 1970).

Constance (1964) maintains that almost everyone would now agree that separate taxa should be delimited wherever significant morphological gaps coincide with boundaries to interbreeding. Where, as found in an increasing number of cases, the two do not coincide, and particularly where significant morphological differences are present, no agreement has as yet been reached. Crossability under artificial conditions is at present considered less important than the behaviour of a population in nature in determining the degree of relatedness. However, the name 'experimental taxonomy' still carries to many the connotation that if one has successfully carried out hybridization, one has experimentally defined the taxonomic limits.

Many taxonomists feel that a species must be more than simply a group of individuals surrounded by a sterility barrier (Constance, 1964). But evidently adhering to the biosystematic definition of the Linnaean species is possible only in groups where a reproduction barrier has been established (Löwe, 1962). Biosystematic experiments, however, have revealed that some character combinations are more indicative for the occurrence of a sterility barrier than others. An experienced taxonomist, when studying such species, is soon able to deduce fairly correctly which taxa are species rather than subspecies, and vice versa. This is, following Löwe (1962), a method fairly similar to that used by Linnaeus and his followers. Even though they knew little about reproductive isolation and its mechanisms, their skill in detecting real limits between species was so profound that biosystematic approaches are only rarely able to improve their conclusions on the species they knew well. But whenever sexually reproducing plants become available for biosystematic study, the conclusions from the morphological approach will be open to correction, though more likely, to confirmation (Löwe, 1962).

The pragmatic or empirical approach to the species problem stresses the need for a practical way of identification and naming based on easily recognizable, mainly morphological characteristics. Information from other sources can be added to define the specific units more clearly. In a sexually reproducing outbreeding species the 'taxonomic' and 'biological' species definitions often coincide (Hawkes, 1970).

This brings us back to the starting point, namely that plant taxonomy aims at the identification of taxa, and the arrangement of these taxa into a scheme of classification that shows their relation. The main way to achieve this is still by morphological studies. Although new techniques in taxonomic research were introduced and new names came into fashion like 'biosystematics', 'experimental taxonomy', 'numerical taxonomy', 'biological species' and so on, the basic aim did not change.

As Hawkes (1970) indicated, a practical way of identification has to be based on easy recognizable characteristics, chiefly morphological. The so-called 'morphological' or 'taxonomic' species concept is not less biological than is the 'biological' species concept advanced by biosystematists. Moreover, 'biosystematics' is not a kind of supra-taxonomy because it uses more sophisticated techniques like cytology, and the computer. There is no basic difference in use between the ruler and the computer. The avoidance of all reference to morphological characteristics in the biological species definition of Mayr (1940), as noted by Löwe (1964), is characteristic for the opinion, that taxonomy is, strictly speaking, not more than a descriptive science, and as such not really modern.

It is open to question if the results of modern research will cause important changes in the delimitations of taxa established by taxonomic research based on representative herbarium collections and field observations. On the other hand the 'traditional' taxonomist should have an open mind for the application of new techniques that might deepen his insight in the interrelationships between taxa. In this respect the 'traditional' taxonomist is at the same time a 'biosystematist'.

Characteristic for classification is the mythical figure of Zizyphus, doomed for eternity to push a heavy stone up the slope of a steep hill, which always slips from his grasp whenever the summit seems to be within reach (Constance, 1964). In taxonomy some new approach or technique is proclaimed every few years, which this time, as Constance puts it, is going to be successfully exploited to get taxonomy over the crest of the ridge dividing intuitive art from exact science. Anatomy, palaeobotany, embryology, palynology, cytology, and genetics, to name a few, all have their advocates. Each time taxonomy is arduously pushed up the hill, it gains from the experience, important new data are incorporated, the basis of classification is broadened and the muscles of Zizyphus the taxonomist doubtless improve considerably; so he will have the strength to perform his task all over again (Constance, 1970). 'Up to the present taxonomy has been, in part, an art, intuitive and descriptive, and of necessity, in part must continue to be so ... the artist and the computer must both be retained' (Sharp, 1962, as quoted by Constance, 1964).

4.2 Taxonomy of cultivated plants

'Cultivated plants are essential to civilization. It is important, therefore, that a precise, stable, and internationally accepted system should be available for their naming' (International Code of Nomenclature of Cultivated Plants, 1969, p. 11, Art. 1). The methods of taxonomy have not been satisfactory for the classification of cultivated plants (Harlan & de Wet, 1971). So, people dealing with cultivated plants (geneticists, agronomists, horticulturalists, and foresters) have developed their own informal and intuitive classifications based on experience to constitute useful groupings. They will continue to do so, no matter what the taxonomist does or does not do (Harlan & de Wet). But there is more involved here than the usual differences in judgement between splitters and lumpers. First, because cultivated plants differ from wild ones and require special taxonomic treatment. Secondly, because there are no guidelines for consistent groupings of related cultivated taxa according to the degree of relationship. Due to human influences, the variation in cultivated plants below the specific level is enormous. Faced with this situation, some traditional taxonomists tend to overclassify. They find conspicuous 'either-or' characteristics, often without intermediates, and frequently base 'species' on them. But these characteristics may be controlled by one or a few genes and thus have little biological significance. Consequently, too many species are named, and then, to accommodate the enormous remaining variability, unreasonable numbers of infraspecific categories may be established (Harlan & de Wet). Jirasek (1966), for example, has proposed 11 categories below the species level; he has listed 57 names that had already been proposed for infraspecific units (Jirasek, 1961).

Formal botanical categories at the infraspecific level do not work, and should not be used. Support for this view goes back as far as De Candolle fil., who vigorously objected to the use of Latin names for artificial horticultural productions (Harlan & de Wet, 1971). Article 40 of the International Code of Botanical Nomenclature (1867), the draft of which was elaborated by De Candolle fil. himself, deals with the nomenclature of cultivated plants, especially those of garden origin: 'Dans les plantes cultivées, les semis, les métis d'origine obscure et les sports, reçoivent des noms de fantasie, en langue vulgaire, aussi différents que possible des noms latins d'espèces ou de variétés. Quand on peut les rattacher à une espèce, à une sous-espèce ou une variété botanique, on l'indique par la succession des noms' (cited by Jirasek, 1961).

Though there is no basic difference between the taxonomy of wild and cultivated plants, cultivated taxa in general do differ in many respects from wild taxa in being not only, like wild taxa, products of evolution through natural selection, but also of conscious and unconscious selection. Consequently, they are often extremely polymorphic; many variants that would have been eliminated in the wild by natural selection have been deliberately maintained by man. Artificial selection has greatly speeded up rates of evolution in cultivated plants; new variants do not only appear and perhaps disappear very quickly, but often undergo rapid modification. Even the gene pool of a cultivated taxon may be subjected to rapid change (Jeffrey, 1968).

The taxonomic consequences are considerable. Whatever system is adopted instead of the botanical system of infraspecific classification, it must deal, according to Jeffrey (1968), with a very large amount of complex variation amongst entities that are themselves continuously changing. It must be sufficiently flexible to accommodate widely differing patterns of variation and their different genetic and evolutionary implications. But at the same time it must be simple, easily applicable, and able to serve practical purposes (Jeffrey, 1968). A classification system emphasizing genetic relations and discontinuities has advantages for plant breeders and others who work with cultivated plants and their wild relatives (Baker, 1970).

A satisfactory classification can be achieved by using correlated studies of e.g. cytology, genetics, genecology, and the variation of cultivated plants and their wild relatives, by both descriptive and experimental methods. Data from archaeology and history are often useful too (Jeffrey, 1968). History shows that without such studies the classification of cultivated plants remains unsatisfactory, and the difficulties of naming many cultivated plants largely arise from lack of such studies on the plants concerned. Such studies should not be carried out without the co-operation of taxonomists, notwithstanding their traditional reluctance to concern themselves with cultivated plants. Lacking this aid, cultivated plants often have been classified by persons not trained in taxonomy, often resulting in numerous invalid and illegitimate names and synonyms, merely producing confusion. In addition, Jeffrey pointed out that misinterpretation of the rules of nomenclature by such persons, and their lack of appreciation of the difference between classification and naming, have discredit classical taxonomy in the eyes of many workers concerned with cultivated plants. Accordingly it has been sometimes asserted that botanical nomenclature cannot accommodate complex crops, such as wheats, potatoes and bananas. This is not so, as formal botanical nomenclature can provide unequivocal binomials for these groups (Jeffrey, 1968).

It is not difficult to design satisfactory artificial classifications for cultivars based on fruit, seed or some vegetative characteristics intended for practical use. Such 'special purpose' classifications merely serve identification but have little other value (Harlan & de Wet, 1971). Contrary to 'general purpose' classifications, in the past called 'natural' classifications, they do not aim at a scheme in which plants are grouped because of their general similarities and are separated from others because of the sum of their differences. According to Hawkes (1970), in both cases the techniques used in classifying cultivated taxa, are similar to those for wild taxa. Morphological characteristics prevail, since they are simplest to recognize and can be easily preserved in dried material, but data on anatomy and geographic distribution may be added, and also the study of cytology, genetics and biochemistry can be included. Most cultivated plants seem to vary almost more within the species than between them, and the wide range of morphological variation in groups of species makes it difficult to arrive at a clear picture of cultivated species on morphology alone. So one is forced to use morphological characteristics, even though they should not be used exclusively, and the 'morphological' species concept, which biosystematists rebel against, turns up

again in a slightly modified form (Hawkes, 1970).

In the opinion of Hawkes the taxonomist working on cultivated plants and related wild taxa must keep to a fairly broad species definition, looking for boundaries and discontinuities in variability patterns, separating species on a reasonably large number of characteristics and making sure that no large and continuous areas of gradation exist between one species and another. If taxonomic work on cultivated taxa is to be of use (chiefly to the plant breeder) the taxonomist must leave the herbarium and turn to the experimental field, the laboratory and, if possible, to the centres of variability of the crop concerned (Hawkes, 1970). Unfortunately, Hawkes considered it unimportant for the taxonomist to return afterwards to the herbarium to study the collected material. This is a significant omission that seems to indicate that the herbarium is an obscure place to be avoided by modern taxonomists studying cultivated plants.

'Cultivated plants are named at 3 main levels: genus, species and cultivar' (International Code of Nomenclature of Cultivated Plants, 1969, p. 12, Art. 7). Jeffrey (1968) considers that for the majority of the cultivated plants, the insertion of two taxonomic ranks between cultivar and species is sufficient. These categories should be empirical units defined to express the taxonomic structure of the crop in question, independent of infraspecific botanical nomenclature. He finally remarks that the terms used to designate these categories must be consistent, unambiguous, and clearly distinct from those designating botanical categories. The system designed by Jirasek (1966) does not meet these requirements. Besides, a common concept of the species is applicable to both wild and cultivated plants, and categories such as 'specioid' (Jirasek, 1964) proposed on this level for cultivated plants should be rejected. It appears necessary to steer a middle course between the over-rigid systems proposed by various East European taxonomists and the hitherto rather slipshod empiricism of the West (Jeffrey, 1968).

Zhukovsky (1967) has proposed four categories between species and cultivar: subspecies, convariety, variety, and concultivar. Jeffrey (1968) has suggested two categories between cultivar and species. Analogous to the term cultivar the categories of higher rank should also end in -var. For the lower he suggests the term provar., for the higher convar. If needed, subordinate categories of both may be designated by the prefix sub-. Obviously, these categories may differ in biological significance for different crops, as do cultivars. They should be given vernacular, not Latin names. This system is a 'general purpose' classification; 'special purpose' classifications will be needed parallel with them for particular ends (Jeffrey, 1968).

In Jeffrey's opinion a problem of classification arises when wild and cultivated taxa belong to the same species. In the most simple cases, cultivated and wild forms are quite identical. Slightly more complex are those in which there is a wild species with one clearly defined cultivated taxon or a cultivated species with one well-defined wild taxon. The most complex cases occur, when the wild forms exhibit complex variation that must have resulted from repeated domestication, escape, and hybridization and introgression between wild and cultivated forms over a long period, as in melons, millets, and wheats. So, Jeffrey considers it important that, for practical reasons,

wild and cultivated taxa be differently designated. He suggests as a possible solution to divide a species containing both wild and cultivated taxa into two distinct units, for which he proposes the category subspecioid. By designating subspecioid units with Latin epithets in single inverted commas, it is also possible to bridge nomenclaturally the gap between the systems employed for wild and cultivated taxa. This proposal to introduce the unit subspecioid does not make much sense, however, since it is unnecessarily complicated, its suggested analogy to the subspecies of natural populations is incorrect, and, besides this, it introduces a new category in formal taxonomy for wild taxa which is unjustifiable.

Harlan & de Wet (1971) have approached the problem from another viewpoint by distinguishing, within the total available gene pool of a crop, the following informal units: (1) primary gene pool, (2) secondary gene pool and (3) tertiary gene pool, to which taxa can be assigned. The primary gene pool corresponds with the biological species; hybridization between taxa is easy and the hybrids are genetically fertile. It almost always includes wild as well as cultivated taxa. The secondary gene pool includes all biological species that will cross with a crop; gene transfer is possible, but barriers are difficult to overcome. In the tertiary gene pool crosses can be made, but hybrids tend to be abnormal, lethal or completely sterile; gene transfer is impossible with available techniques or rather extreme measures are required.

Harlan & de Wet propose to divide the biological species (= primary gene pool) into two subspecies: subspecies 'A' containing the cultivars, and subspecies 'B' the spontaneous taxa. For both the terms race and subrace are proposed to indicate lower units; for cultivated taxa categories below the level of subrace like cultivar and line, clone or genotype are available. A race has a distinct cohesion of morphology, geographic distribution, ecological adaptation and frequently of breeding behaviour. A subrace is simply a convenient division of a race and must be reasonably recognizable. It is stressed that races and subraces are not intended to be formal categories so that they are not italicized.

This concept of subspecies differs from that used in formal taxonomy, where it denotes a taxon distinct from other taxa within the same species and, most important, geographically separated from them. It is incorrect to attribute to the term subspecies a meaning different from the current one, and to use the categories race and subrace for the wild infraspecific taxa. The lowest category recognized under the Code is the cultivar (Art. 10). Although cultivars may differ in their modes of reproduction (Art. 11), the recognition of line, clone or genotype as infraspecific categories below the cultivar, as is proposed by Harlan & de Wet, is against the Code and should be rejected.

Nevertheless, it may be practical to separate the wild and cultivated taxa of a species, but the introduction of a special category such as subspecies or subspecioid to designate the two taxa, however, is superfluous and undesirable. At best a category name could be proposed to designate the entire complex of cultivated taxa (in essence cultivars) within a species containing both wild and cultivated taxa. Category names such as (sub)convar. and (sub)provar., denoting groups of cultivars, seem sensible,

being practical and fitting well into the framework of the International Code of Nomenclature of Cultivated Plants (1969).

There is not yet any general consensus on the nomenclature for groups of cultivars. Consequently, none of the proposed terms is used in this publication. Every cultivated taxon denoting a group of cultivars is called a 'cultivar-group' (cv.-group), such as *Vigna unguiculata* cv.-group Unguiculata (the common cowpea) or *V.u.* cv.-group Biflora (the catjang cowpea). Within these cv.-groups cultivars may be designated, like cv. Ras Makonnen of the cv.-group Unguiculata.

5 Pulse crops in Ethiopia

5.1 Pulses in Ethiopian agriculture

In many parts of Ethiopia pulses are a daily food and an important source of protein, especially during the numerous fast days. They are cultivated for local consumption, but are also exported, mainly to Ceylon, Japan, the Arabian Peninsula, and West European countries. They rank second as food after the cereals, occupying about 1/6 of the area planted to cereals (Omero Sabatini & Samuel, 1969).

The dominant pulses are chickpea *(Cicer arietinum* L.*)*, pea *(Pisum sativum* L. cv.-group Sativum, *P.s.* cv.-group Abyssinicum*)*, horse bean *(Vicia faba* L. cv.-group Minor, *V.f.* cv.-group Faba*)*, lentil *(Lens culinaris* Med.*)* and common bean *(Phaseolus vulgaris* L.*)*. Chickpea, pea, horse bean and lentil are of great importance in the grain-plough complex of the central Ethiopian Highlands, whereas common bean is prominent in the sorghum-plough complex of the highland region of Hararge.

Pigeon pea *(Cajanus cajan* (L.) Millsp.*)*, hyacinth bean *(Dolichos lablab* L.*)*, grasspea *(Lathyrus sativus* L.*)*, Egyptian lupin *(Lupinus albus* L. cv.-group Albus*)*, lima bean *(Phaseolus lunatus* L. cv.-group Lunatus, *P.l.* cv.-group Inamoenus*)*, fenugreek *(Trigonella foenum-graecum* L.*)* and cowpea *(Vigna unguiculata* (L.) Walp. cv.-group Unguiculata, *V.u.* cv.-group Biflora*)* sometimes are locally of limited importance.

Jack bean *(Canavalia ensiformis* (L.) DC.*)*, *Canavalia virosa* (Roxb.) Wight & Arn., velvet bean *(Mucuna pruriens* (L.) DC. cv.-group Utilis*)* and *Psophocarpus palustris* Desv. are rarely found, whereas scarlet runner bean *(Phaseolus coccineus* L.*)* and mung *(Phaseolus radiatus* L.*)* are only incidentally met with.

Not included are the following edible Ethiopian *Papilionaceae.*

Arachis hypogaea L.: this oilcrop will be treated under the Ethiopian oilcrops in a later study.

Astralagus boeticus L.: seeds used as a substitute for coffee (south-west Ethiopia, vide Fiori, 1939; not collected).

Canavalia gladiata (Jacq.) DC.: a vegetable (Shoa, vide Cufodontis, 1955; not collected).

Eriosema cordifolium A. Rich.: wild, plant with edible tuberous roots (north-west Ethiopia, Shoa, north Hararge, vide Cufodontis, 1955; Lemordant, 1971; not collected).

Phaseolus aconitifolius Jacq.: a pulse (Eritrea, vide Cufodontis 1955; not collected).

Phaseolus acutifolius A. Gray: a pulse (Hararge, vide Fiori, 1939; not collected).

Phaseolus angularis (Willd.) W. F. Wight: a pulse (Hararge, exp. field College of Agriculture, H.S.I.U., vide Westphal 2511).

Sphenostylis stenocarpa (Hochst. ex Rich.) Harms: a pulse and root crop (west Eritrea, west Tigre-Begemdir, vide Cufodontis, 1955; not collected).

Vigna mungo (L.) Hepper: a pulse (Tigre-Begemdir-Wollo, Shoa ?, south-west Ethiopia, vide Cufodontis, 1955; not collected).

Vigna vexillata (L.) A. Rich.: wild, plant with edible tuberous roots (Eritrea, Tigre-Begemdir-Wollo?, Shoa, south-west Ethiopia, Hararge, vide Cufodontis, 1955; Harms, 1911). According to Purseglove (1968) the tuberous roots are eaten in the same way as sweet potatoes in the Sudan and Ethiopia. Tuber and root crops are to be studied later on.

5.2 Key based on general characteristics

1 a. Leaves digitate, ca 7-foliolate. Terminal inflorescence with many flowers. Pod narrowly oblong, laterally compressed, bulging over the seeds, ca 8.5–10.0 × 1.5–2.0 cm, beaked, ca 5-seeded . . . . . 8A *Lupinus albus* cv.-group Albus

b. Leaves pinnate. Other characteristics not associated 2

2 a. Leaves tri-foliolate 8

b. Leaves not tri-foliolate 3

3 a. Leaves with a top leaflet. Leaflets partly dentate. Flowers small, ca 1.0 cm long, red-purple or white. Pod inflated, 1.5–2.0 cm × ca 8 mm, glandular-pubescent, ca 2-seeded . . . . . 4 *Cicer arietinum*

b. Leaves without a top leaflet. Other characteristics not associated 4

4 a. Tendril absent, only a subulate, partly foliaceous mucro present which is much shorter than the leaflets. Stems square. Flowers ca 2.5 cm long, white with a dark brown spot on each wing. Pod narrowly oblong, cylindrical to flattened . . . . . 14 *Vicia faba*

b. Tendril present, about equal to or longer than the leaflets. Other characteristics not associated 5

5 a. Leaf with one pair of leaflets 6

b. Leaf with more than one pair of leaflets 7

6 a. Leaflets entire, narrowly elliptic–oblong. Pod with 2-winged upper margin. Stems winged. Stipules conspicuous, smaller than the leaflets, narrowly triangular with a smaller but similarly shaped basal appendage and often with a small tooth in between, ca 1.5 cm long. Flowers ca 1.5 cm long, violet-blue to red-purple . . . . . 6 *Lathyrus sativus*

b. Leaflets partly dentate, as a rule ovate to obovate. Pod without winged upper margin. Stems ribbed. Stipules obliquely ovate to -obovate, leaf-like, larger than the leaflets, more than 1.5 cm long. Flowers 1.0–1.5 cm long, red-purple (turning violet-blue) . . . . . 11A *Pisum sativum* cv.-group Abyssinicum

7 a. Leaflets ca 1.0–1.5 cm long, entire. Stipules small, ca 5 mm long. Stems square. Flowers ca 5 mm long, light violet-blue to whitish. Pod oblong, laterally compressed, ca 13 × ca 6 mm, 1–2-seeded . . . . . 7 *Lens culinaris*

b. Leaflets ca 2.5–6.5 cm long, entire or dentate. Stipules prominent, larger than the leaflets, leaf-like. Stems terete–angular. Flowers ca 2.0 cm long, white or red-purple (in the latter case turning to violet-blue to blue). Pod oblong, ca 5.0–8.0 × ca 1.0–1.5 cm, ca 6–8-seeded . . . . . 11B *Pisum sativum* cv.-group Sativum

8 a. Highly aromatic herb. Leaflets obovate, ca 1.5–3.0 × ca 0.5–1.5 cm, tapering towards the base, almost glabrous. Inflorescence as a rule single-flowered. Flowers small, ca 1.5

cm long, pale yellow. Pod linear, conspicuously beaked, ca 12.0–15.0 cm × ca 2–4 mm, ca 10–15-seeded . . . . . 13 *Trigonella foenum-graecum*

b. Plants not aromatic. Other characteristics not associated 9

9 a. Pod 4-winged along the angles, square in cross section, ca 7.0–10.0 × ca 1.5 cm. Inflorescence many-flowered. Flowers ca 3.0 cm long, pale blue-violet, arising 1–3 together from tubercles on rachis. Bracteoles prominent, ovate, ca 5–10 mm long, fleshy, persistent, at base often auricled . . . . . 12 *Psophocarpus palustris*

b. Pod not 4-winged. Other characteristics not associated 10

10 a. Pod with prominent longitudinal ribs 11

b. Pod without longitudinal ribs 13

11 a. Pod with at least one complete prominent rib on either valve, and with 2–3 usually less prominent parallel, mostly partial ribs, oblong, somewhat laterally compressed, ca 7.0–9.0 × ca 1.8 cm, covered with fine, white to light brown pubescence, ca 3-seeded. Flowers ca 3.0 cm long, dark purple . . . . . 9A *Mucuna pruriens* cv.-group Utilis

b. Pod with one complete sutural rib on either valve and another complete prominent parallel rib just below it. Pod flattened dorsally. Other characteristics not associated . . . 12

12 a. Pod up to ca 30.0 × ca 3.0 cm, ca 10–20-seeded. Flowers purple. Seeds as a rule white; hilum surrounded by an orange-brown line . . . . . 2 *Canavalia ensiformis*

b. Pod up to ca 15.0 × ca 3.0 cm, ca 2–6-seeded. Flowers ca 2.5 cm long, purple. Seeds not white; hilum surrounded by a dark brown line . . . . . 3 *Canavalia virosa*

13 a. Stipules as a rule appendaged, spurred or auriculate 14

b. Stipules neither appendaged nor spurred or auriculate 18

14 a. Bracteoles prominent, ovate, ca 5–10 mm long, persistent, fleshy, often auricled at base. Flowers ca 3.0 cm long, pale blue-violet . . . . . 12 *Psophocarpus palustris*

b. Bracteoles smaller, up to ca 5 mm long, deciduous or subpersistent. Other characteristics not associated 15

15 a. Stamens monadelphous. Pod oblong, with one complete sutural rib on either valve and another complete prominent parallel rib just below it . . . . . *Canavalia*

b. Stamens diadelphous. Pod linear 16

16 a. Hispid, bushy herb. Flowers ca 1.0 cm long, yellow. Keel with one conspicuous 'pocket'. Pod linear–cylindrical, ca 6.0–9.0 cm long, with dark brown, short, bristly hairs, dark brown to black when mature . . . . . 10C *Phaseolus radiatus*

b. Nearly glabrous, bushy or climbing herb with scattered, usually widely spaced minute spinelets on stems. Flowers violet. Pod linear, slightly laterally compressed or subcylindrical, ca 8.0–20.0 cm long, with ± curved beak being dorsally flattened and grooved or concave, glabrous or nearly so, minutely verruculose, light brown, sometimes purplish tinged 17

17 a. Young pods erect to spreading. Mature pods spreading and at last often pendent, up to ca 12.0 cm long. Seeds as a rule oblong, ca 5–7 × 5 mm . . . . . 15B *Vigna unguiculata* cv.-group Biflora

b. Young pods as a rule spreading to pendent. Mature pods always pendent, longer than 12.0 cm. Seeds ± square, ca 7–9 × 6–8 mm . . . . . 15A *Vigna unguiculata* cv.-group Unguiculata

18 a. Rachis of the inflorescence tuberculate. Flowers ca 1.5 cm long, white or purple. Pod with persistent style, crescent-shaped to more or less straight and oblong, or also dorsally straight and ventrally deeply curving, terminally abruptly crooked, acuminate and topped

by a slender, curved beak, tuberculate along both margins, sometimes grooved above, ca 5.0–10.0 × ca 1.5–3.0 cm . . . . . 5 *Dolichos lablab*

b. Rachis of the inflorescence not tuberculate. Other characteristics not associated . . 19

19 a. Inflorescence with 1–2 flowers 20

b. Inflorescence with more than 2 flowers 21

20 a. Flowers small, ca 1.5 cm long, pale yellow, as a rule one flower per inflorescence. Pod linear, conspicuously beaked, ca 12.0–15.0 cm × ca 2–4 mm, ca 10–15-seeded . . . . . .13 *Trigonella foenum-graecum*

b. Flowers large, ca 3.0 cm long, dark purple, as a rule two flowers per inflorescence . . . . . 9a *Mucuna pruriens* cv.-group Utilis

21 a. Shrub, glandular-pubescent, especially on calyx and pods. Flowers ca 1.5–2.0 cm long, yellow or yellow to reddish. Pod crescent-shaped, slender, laterally compressed, impressed between and bulging over the seeds, ca 9.0–11.0 × ca 1.5 cm . . . . . .1 *Cajanus cajan*

b. Climbing or bushy herbs, not glandular-pubescent, but slightly pubescent. Other characteristics not associated 22

22 a. Key on floral characteristics 23

b. Key on pod characteristics 25

23 a. Flowers ca 2.5 cm long, orange-red. Standard ca 1.7 × ca 1.7 cm, glabrous except for some abaxial hairiness at the top. Wings ca 2.5 cm long. Vexillary stamen appendiculate near the base . . . . . 10A *Phaseolus coccineus*

b. Flowers coloured otherwise. Other characteristics not associated 24

24 a. Flowers ca 1.5 cm long, yellow-green. Standard ca 1.0 × ca 1.1 cm, finely pubescent abaxially. Wings ca 1.2 cm long, projecting forward. Vexillary stamen with a swollen base . . . . . 10B *Phaseolus lunatus*

b. Flowers ca 2.0 cm long, white (turning yellow-orange) or light red-purple (turning yellow-white). Standard ca 1.3 × ca 1.4 cm, glabrous. Wings ca 2.0 cm long, projecting forward. Vexillary stamen appendiculate near the base . . . .10D *Phaseolus vulgaris*

25 a. Pod linear, sometimes (slightly) curved, laterally compressed, ca 9.0–18.0 × ca 1.0–1.5 cm, ca 5–7-seeded. Pod wall almost smooth to finely striate or rugulose. Dorsal suture ± ridged. (Mature) pods frequently with purple or violet spots or stripes, sometimes nearly purple. Seeds separated by various amounts of intermediate (sept-like) tissue . . . . . .10D *Phaseolus vulgaris*

b. Pod neither linear nor (slightly) curved, up to 3-seeded. Other characteristics not associated 26

26 a. Pod more or less crescent-shaped, laterally compressed, ca 9.0–13.0 × ca 1.8 cm. Pod wall rough with small oblique ridges and slightly tuberculate, ca 3-seeded. Seeds separated by various amounts of intermediate (sept-like) tissue . . 10A *Phaseolus coccineus*

b. Pod widely varying in size, as a rule broadly sword-shaped, laterally compressed, ca 5.0–12.0 × ca 1.5–3.0 cm. Sometimes top hook-shaped. Pod wall ± striate. Dorsal suture ± flat and uneven. Mature pods sometimes with red-brown spots, ca 2–3-seeded. Not septate . . . . . 10B *Phaseolus lunatus*

5.3 Key based on seed characteristics[4]

Sometimes mixtures of pulses included in this key are found at the market places like *Pisum sativum* and *Vicia faba*, *Phaseolus vulgaris* and *Vigna unguiculata*, *Cajanus cajan* together with *Dolichos lablab* and *Phaseolus vulgaris*, *Phaseolus radiatus* and *Vigna unguiculata*, etc.

For the morphology of the seed types see Figure 1.

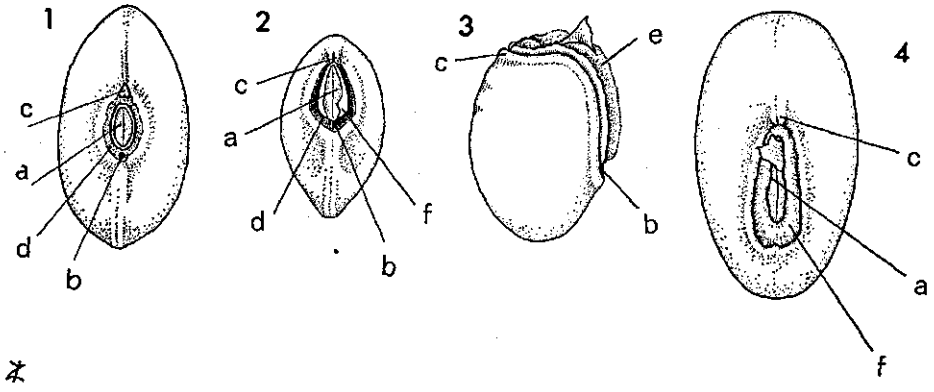

Fig. 1. Seed types (2½×). – 1. *Phaseolus vulgaris* cv. Pearly Wonji; 2. *Vigna unguiculata* cv. Ras Makonnen; 3. *Dolichos lablab* cv. Brown Sagan; 4. *Mucuna pruriens* cv. Velvet Gimbi. – a. hilum; b. micropyle; c. twin-bump; d. ring around hilum ('corona'); e. aril covering the hilum; f. rim-aril.

1 a. Seeds with aril (rim-like or completely covering the hilum) 2
b. Seeds without aril 5

2 a. Aril completely covering the hilum, extending over 2 sides of the seed (rounding one corner); hilum ca 10 mm long; seeds as a rule ovoid and laterally compressed, ca 9–12 × 6.5–9 mm, white, black, red-brown, black with red-brown spots, brown with dark brown or black spots, as well as white with partly brown . . . . . 5 *Dolichos lablab*
b. Aril rim-like, not rounding one corner. 3

3 a. Aril prominent, with a scale-like extension at the rim; hilum as a rule excentric, ca 4 mm long; seeds oblong-ellipsoid, laterally somewhat compressed, ca 15 × 10 mm, light brown with dark brown mosaic . . . . . 9A *Mucuna pruriens* cv.-group Utilis
b. Aril slightly developed, with scale or rim more or less developed; hilum excentric.... 4

4 a. Seeds ± square, sometimes rounded, ca 7–9 × 6–8 mm, brown, sometimes light brown with (dark) violet mosaic, or white with a brown ring around hilum. . . . . 15A *Vigna unguiculata* cv.-group Unguiculata[5]
b. Seeds as a rule not square but oblong, ca 5–7 × 5 mm, red, light brown, black, light brown with brown mosaic or light brown with greyish and/or violet mosaic . . . . . 15B *Vigna unguiculata* cv.-group Biflora[5]

4. Excluding *Psophocarpus palustris*.
5. Intermediate types between cv.-group Unguiculata and cv.-group Biflora occur, being the result of crossing.

5 a. Seeds with a prominent twin-bump near the hilum at the opposite side of the micropyle 6
b. Seeds without a prominent twin-bump 9

6 a. Seeds small, ellipsoid to ± globular, sometimes square–cylindric, ca 2.5–5 × 3–4 mm, usually dull green, sometimes light brown; testa sometimes mealy, and usually marked with fine wavy ridges with close parallel riblets perpendicularly between, making the seeds not smooth to the touch; hilum ± central . . . . . 10C *Phaseolus radiatus*
b. Seeds larger 7

7 a. Seeds as a rule kidney-shaped or ± rhomboid, laterally compressed, variable in size, ca 12–24 × 9–13 mm, transverse lines radiating from the hilum to the opposite edge of the seed, white, white with one red-purple ending and otherwise spots or mosaic (large-seeded cvs), red-purple, red-purple with lighter coloured spots, brown to red-purple with darker coloured mosaic, whitish with purple mosaic, white with violet mosaic, sometimes nearly violet, white with black mosaic, sometimes nearly black, violet, or dark violet to black (medium and small-seeded cvs) . . . . . 10B *Phaseolus lunatus*
b. Seeds otherwise 8

8 a. Seeds variable in shape, as a rule ellipsoid–oblong, laterally compressed, ca 18–22 × 13 mm, shiny black with purple mosaic; hilum ca 5.5 mm long . . . 10A *Phaseolus coccineus*
b. Seeds smaller, very variable in shape, size and colour, as a rule oblong, but also ellipsoid, globular or kidney-shaped, as a rule laterally compressed, ca 8–17 × 5–7 mm, white, purple, black, ochre, brown, and with stripes or mosaic; hilum ca 2–3.5 mm long, often surrounded by a darker coloured hilum-ring . . . . . 10D *Phaseolus vulgaris*

9 a. Seeds lens-shaped, ca 4 mm in diam., grey-brown with black spots or grey-black with brown spots; cotyledons orange . . . . . 7 *Lens culinaris*
b. Seeds not lens-shaped 10

10 a. Seeds globose, 5–8 mm in diam. 11
b. Seeds not globose. 12

11 a. Seeds always with black hilum, smooth, sometimes very slightly wrinkled, slightly glossy, 5–7 mm in diam., dark violet, grey-green, brown, or grey-brown to brown with violet spots . . . . . 11A *Pisum sativum* cv.-group Abyssinicum
b. Seeds rarely with black hilum, but usually brownish, smooth or slightly wrinkled, not glossy, 6–8 mm in diam., white with an orange tinge, green, orange-brown to brown, dark violet, green or brown with violet spots or with mosaic pattern . . . . . 11B *Pisum sativum* cv.-group Sativum

12 a. Seeds beaked, angular, sometimes ± globular, wrinkled, sometimes smooth, ca 7 × 6 mm; hilum sunken; chalazal tubercle as a rule prominent, ± heart-shaped; brown, black, white with an orange tinge, rarely either marbled or with black spots . . . . . 4 *Cicer arietinum*
b. Seeds not beaked 13

13 a. Seeds obliquely furrowed on each side near the edge, giving the seeds a hooked appearance, irregularly shaped, laterally compressed, ca 5 × 3 mm, smooth or wrinkled, greenish-brown, dark brown, rarely either whitish or violet speckled; aromatic . . . . . 13 *Trigonella foenum-graecum*
b. Seeds not obliquely furrowed 14

14 a. Seeds square–rectangular with rounded corners, laterally compressed, sometimes wrinkled, ca 9–14 × 8–12 mm, cream; hilum at one corner, sunken, yellowish . . . . . 8A *Lupinus albus* cv.-group Albus
b. Seeds not square–rectangular 15

15 a. Seeds wedge-shaped, ca 4–7 mm, mostly grey to brown and marbled, sometimes light green or brown . . . . . 6 *Lathyrus sativus*
b. Seeds not wedge-shaped 16

16 a. Hilum on the short end of the seed (not laterally), prominent, black; seeds variable in shape and size, oblong to obovate, generally bolster-shaped or compressed; ca 10 × (less) 10 mm, sometimes ca 20–25 × 15–18 mm, dark brown, brown, reddish or green . . . . . 14 *Vicia faba*
b. Hilum not on the short end of the seed, but laterally 17

17 a. Seeds oval–round, flattened at side of hilum, ca 6.5–8.5 × 6.5–7.5 mm, surface minutely shallowly pitted, either greyish with some small red-brown spots (hilum bordered red-brown) or greyish with marked irregular red-brown spots. It is possible to let the seed stand upright by placing it on the hilum . . . . . 1 *Cajanus cajan*
b. Seeds oblong 18

18 a. Seeds laterally compressed, ca 20 × 15 mm; hilum less than half of the length of the seed, surrounded by an orange-brown line; white . . . . . 2 *Canavalia ensiformis*
b. Seeds ± laterally compressed, ca 15–20 × 9–13 mm; hilum more than half of the length of the seed, surrounded by a dark brown line; light yellowish-brown with darker coloured stripes; testa very hard . . . . . 3 *Canavalia virosa*

5.4 Arrangement of the text

Eighteen species, all *Papilionaceae*, are arranged alphabetically. Eleven belong to the tribe *Phaseoleae* (from the genera *Cajanus* DC., *Canavalia* Adans. emd. DC., *Dolichos* L., *Mucuna* Adans., *Phaseolus* L., *Psophocarpus* Neck. ex DC. and *Vigna* Savi; 11 cultivated taxa). Five belong to the tribe *Vicieae* (from the genera *Cicer* L., *Lathyrus* L., *Lens* P. Mill., *Pisum* L. and *Vicia* L.; 6 cultivated taxa). One belongs to the tribe *Genisteae* (*Lupinus* L., with one cultivated taxon), and one to the tribe *Trifolieae* (*Trigonella* L., with one cultivated taxon).

The important role of *Phaseolus* species is discussed under this genus. A historical account is given of the problem how to distinguish the genera *Phaseolus* and *Vigna*, and a list of relevant literature is included.

Each species is headed by its botanical name; the somatic chromosome number (from Frahm-Leliveld, 1957), if available from Ethiopian material; and a reference to (a) figure(s) and as a rule to (a) plate(s) as well. Strictly botanical literature is mainly mentioned under the heading 'Synonyms'.

The 'Literature' gives a chronological list of references to taxonomic (tax.), agricultural (agric.) and other literature.

'Botany' is based on material collected in Ethiopia.

'Taxonomic notes' deal with the typification, relevant taxonomic and morphological questions, the designation of cultivar names, the differences observed between plants raised at Wageningen and in Ethiopia, and the specimens examined (arranged according to province).

Under 'Geographic distribution', 'Ecology', 'Husbandry' and 'Uses' first information is provided on the crop for the whole world, followed by information relevant for Ethiopia.

The data on 'Protein content' are from literature.

For botanical terms the following works should be consulted: B. D. Jackson, A glossary of botanic terms, London, 1965; and G. H. M. Lawrence, Illustrated glossary of taxonomical terms, in: Taxonomy of vascular plants, New York, 1966.

(1) Cajanus cajan (L.) Millsp. — Fig. 2; Plate 1

'*Cajanus*': derived from the Malay plant name 'katjang' by which some pod or bean is meant. In foreign ears the word 'katjang' sounded like 'cajan' and this vernacular name, thus spelt, was latinized as 'Cajanus'.
'*cajan*': see above.

Millspaugh, Publ. Field Columb. Mus. Bot. 2: p. 53 (1900).
Type: Ceylon; '*Cytisus* racemis axillaribus erectis ... intermedio longius petiolato'; Hermann Herb. I, fol. 14 (BM,lecto.!).

Synonyms
Cytisus cajan L., Sp. Pl. ed. 1: p. 739 (1753) (basionym).
Cytisus pseudocajan Jacq., Hort. Vind. 2: p. 54, t. 119 (1772).
Cajan inodorum Med., Vorles. Churpf. Phys. Ges. 2: p. 363 (1787).
Cajanus flavus DC., Cat. Hort. Monsp.: p. 85 (1813).
Cajanus bicolor DC., l.c. p. 86.
Cajanus indicus Spreng., Syst. Veg. ed. 16, 3: p. 248 (1826).
Cytisus guineensis Schum., in: Schum. & Thonn., Beskr. Guin. Pl.: nr. 208 (1827) (Danske Vid. Selsk. Afh. 4: p. 123 (1829)).
Cajanus cajan f. *bicolor* (DC.) Baker, vide Cufodontis (1955).
Cajanus cajan var. *bicolor* (DC.) Purseglove?, Trop. Crops, Dicotyl. 1: p. 237 (1968).
Cajanus cajan var. *flavus* (DC.) Purseglove?, l.c.

Literature

1813: De Candolle, Catalogus ... Monspeliensis: p. 85. (tax.)
1931: Ochse, Indische groenten: p. 370-372. (agric.)
1939: Amshoff, Flora Suriname 2 (2): p. 213-214. (tax.)
1953: Whyte et al., Legumes in agriculture: p. 256-257. (agric.)
1955: Cufodontis, Enumeratio, Bull. Jard. bot. État Brux. 25 (3): p. 321. (tax.)
1958: Kuls, Frankf. Geogr. Hft 32: p. 109. (agric.)
1962: Gooding, Fld Crop Abstr. 15: p. 1-5. (agric.)
1964: Aykroyd & Doughty, Legumes in human nutrition: p. 102, 117. (agric.)
1964: Hutchinson, The genera of flowering plants 1: p. 350-352, 420-421. (tax.)
1965: Busson, Plantes alimentaires de l'ouest africain: p. 236-237. (agric.)
1966: Burkill, Dict. ec. prod. Malay Peninsula 1: p. 398-400. (agric.)
1966: Stanton et al., Grain legumes in Africa: p. 91-93. (agric.)
1966: Terra, Tropical vegetables: p. 34. (agric.)
1968: Purseglove, Tropical crops, Dicotyl. 1: p. 236-241. (tax. + agric.)
1970: Pathak, in: Kachroo, ed., Pulse crops of India: p. 14-53. (agric.)
1971: Verdcourt, in: Fl. Trop. East Africa, Leg. 4, Papil. 2: p. 709-711. (tax.)

Local names: yewof-ater (Amarinia); ohota-farengota (Konso); salboco-ghed (Somali).
Trade names: pigeon pea, Angola pea, Congo pea, red gram, no-eye pea, yellow dhal (English); ambrévade, pois d'Angole, pois pigeon (French).

Geographic distribution

Probably pigeon pea is a native of Africa, where it is sometimes found wild or naturalized. It is of ancient origin, and cultivated in Egypt already during the XII-th Dynasty, or some time before 2000 B.C., when Egypt had established trade-relations with tropical Africa and Syria. Pigeon peas were cultivated in Madagascar from very early times. Probably they were taken to India in pre-historic times, where a centre of diversity with the largest number of cultivars has developed. The crop was brought to the New World in early post-Columbian days, but it did not reach the islands of the Pacific until in comparatively recent times. Pigeon peas are now widely spread throughout the tropics and subtropics (Purseglove, 1968).

In Ethiopia it is found in the Konso region, where it probably is an Italian introduction, and sometimes in Hararge, but rarely in other regions. Perhaps it is cultivated in the extreme western part of Ethiopia, but no references are available. Only once seeds were found in a market place (Giarso in Konso).

Description

An erect, branching, shrubby, glandular, pubescent annual (or short-lived perennial); taproot well-developed.

Stems ± terete (young stems angled), ribbed, much-branched, becoming woody with age, densely appressed-pubescent or felty, sometimes with yellowish, globular excretions.

Stipulae small, narrowly ovate-triangular, acuminate or acute at top.

Leaves alternate, 3-foliolate. Petiole (1.0–)1.5–6.0(–8.0) cm long, ribbed, grooved above and flattening towards the top, like the rachis, topped by a leaflet, (0.5–)1.0–2.5(–3.0) cm long.

Leaflets: First two leaflets opposite and ± asymmetrical, top leaflet symmetrical and longer, with petiolule short, grooved above and densely pubescent, ovate-elliptic, rarely narrowly so, (4.5–)5.0–10.5(–13.5) × (1.5–)2.0–5.0(–6.5) cm, entire, cuneate at base, acuminate at top, green and finely and densely puberulous (velvety to the touch) above, grey-green with prominent silvery hirtellous venation and on surface of lamina short velvety beneath (as above), furthermore on both sides (particularly beneath) with numerous small, yellowish, globular excretions.

Stipellae small, subulate, at the base of the petiolule, 1 per lateral leaflet, 2 per top leaflet.

Inflorescence an axillary raceme with many flowers. Peduncle more or less compressed towards the top, (0.5–)2.0–4.0(–5.0) cm long, irregularly pubescent (scattered, glandular hairs with bulbous base present); rachis small; bracts 1 per flower, deciduous, variable in shape (as a rule ovate), (5–)8(–10) × ca 3.5 mm, acuminate at top, frequently with glandular hairs with bulbous base; pedicels 1.0–1.5(–2.0) cm long, densely pubescent with scattered glandular hairs with bulbous base, sometimes with purple spots.

Calyx campanulate with numerous glandular hairs with bulbous base; tube gibbous dorsally, ca 5 mm long; lobes 5, subequal, narrowly triangular, 4–7 mm long, the smaller upper lobes paired (4–5 mm long), free or partly connate.

Corolla: Standard erect and spreading, more or less orbicular, (17–)19–20(–22) × (16–)18–20 mm, clawed, bi-auriculate, bi-'pocketed', obcordate and slightly mucronate at top, glabrous, yellow, abaxially reddish or yellowish with red striations, adherent to the wings by the auricles. Wings obovate, 18–20 × ca 7 mm, clawed, as a rule asymmetrically bi-auriculate, slightly 'pocketed', obtuse at top, glabrous, yellow, sometimes partly reddish, slightly adherent to the keel. Keel boat-shaped, ca 17 × ca 7 mm, clawed, entirely split dorsally, ventrally split near the base, left and right lengthwise furrowed, glabrous, yellow-green, sometimes top reddish.

Androecium: Stamens diadelphous (9 + 1). Vexillary stamen free, ca 15(–18) mm long, flattening towards the base, tapering towards the top, geniculate near the base. Staminal sheath ca 12 mm long when, on either side, the first filament is released; this is generally followed by 3 single stamens while the top stamen is finally released; free part of filaments alternatingly longer and shorter, (3.5–)5(–7) mm long. Anthers ellipsoid, ca 1 mm long, dorsifixed, light brown.

Gynoecium: Ovary sessile or nearly so, ca 8 mm long, velvety hairy, long-beaked, ca 5-ovulate. Style abruptly upturned, ca 12 mm long, thickened below the stigma, glabrous. Stigma capitate, glandular-papillate.

Pod crescent-shaped, slender, laterally compressed, impressed between and bulging over the seeds, (8.0–)9.0–11.0(–13.0) × 1.0–1.5(–1.7) cm, conspicuously beaked, pubescent with frequent glandular hairs with bulbous base, usually more or less purple, 3–6-seeded.

Seeds subglobose to ellipsoid, 6.5–8.5 × 6.5–7.5 mm, slightly laterally compressed, flattened at side of hilum, surface minutely shallowly pitted, either greyish with some small red-brown spots (hilum bordered red-brown) or greyish with marked irregular red-brown spots. Hilum small, elliptic, seemingly white by the persistent remnant of the funiculus. Cotyledons light yellowish.

Seedling with hypogeal germination. Epicotyl green. First two leaves opposite, simple, narrowly ovate, (3.5–)4.5–7.0(–8.0) × (1.0–)1.5–2.0(–2.5) cm, rounded at base, acuminate at top, sometimes slightly dented at edge, with yellowish excretions. Stipulae of the two leaves sometimes partly connate.

Notes

1. In practice it is possible to let the seeds stand upright by placing them on the hilum.
2. Plants raised in the greenhouse at Wageningen only flowered and set fruit under short-day circumstances.

Taxonomic notes

(1) In Sp.Pl. ed. 1 Linnaeus maintained the diagnostic analysis of this taxon already established in his Flora Zeyl. no. 279. He considered the description in Flora

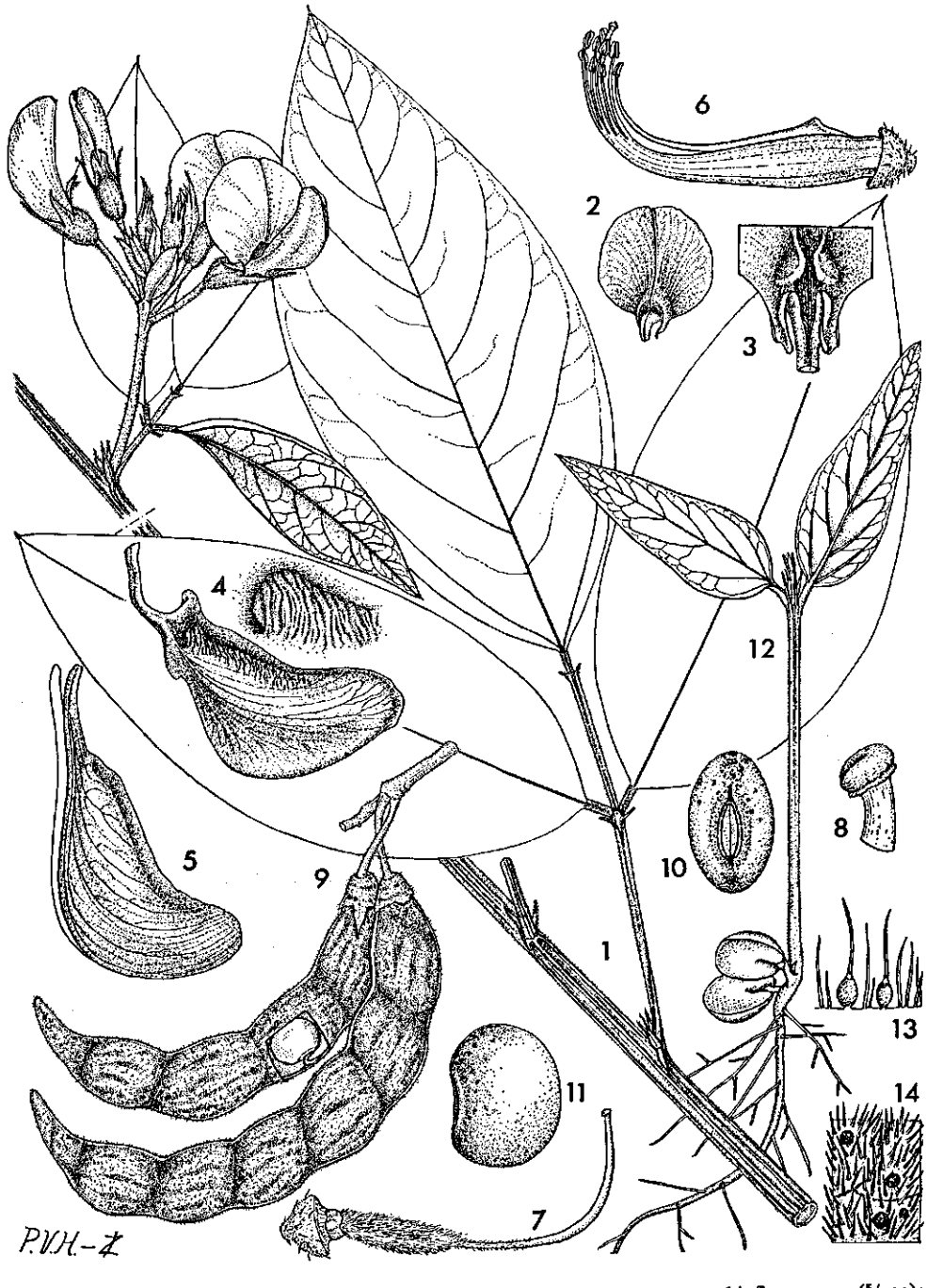

Fig. 2. *Cajanus cajan* (L.) Millsp. cv. Duke of Harar. – 1. branch with leaves and inflorescence (5/6 ×); 2. standard, abaxial view (5/6 ×); 3. standard, basal part (2½ ×); 4. wing, abaxial view (2½ ×) with detail of 'pocket' (ca 5 ×); 5. keel (2½ ×); 6. staminal sheath (2½ ×); 7. pistil + disk (2½ ×); 8. stigma (15 ×); 9. pods (5/6 ×); 10. seed, with hilum (2½ ×); 11. seed, lateral view (2½ ×); 12. seedling (5/6 ×); 13. hairs on calyx (25 ×); 14. hairs and globular excretions on upper leaflet surface (25 ×). – 1. WP 8631; 2–8. WP 8631 (spirit mat.); 9. WP 3512 (spirit mat.); 10–11. WP 3512; 12. WP 7529 (spirit mat.); 13. WP 8631 (spirit mat.); 14. WP 8631.

Zeyl. (l.c. p. 128-129) as good, since he referred in Sp.Pl.ed.1 to Flora Zeyl. with an *. In Flora Zeyl. Linnaeus added to the diagnosis a description which gives the following information about the fruits: 'Legumina torosa, dissilientia in contortas spirales valvulas' (l.c. p. 129).

In the Herbarium of Paul Hermann four specimens of *Cytisus cajan* L. *(Cajanus cajan)* are present: I, fol. 14 (1 specimen); II, fol. 76 (1 specimen); and III, fol. 30 (2 specimens). The first specimen (I, fol. 14) is the only one which carries both flowers and well-developed fruits. It carries in Linnaeus's handwriting his diagnosis of this taxon in Hort. Cliff. p. 354. Stearn (1972) designated this specimen in Hermann's Herb. (I, fol. 14 of Flora Zeyl. no. 279) as the lectotype of *Cajanus cajan* (L.) Millsp., which choice is followed here.

Verdcourt (1971) did not actually typify the pigeon pea, but referred to Hermann's specimens in II, fol. 76 and III, fol. 30 as being syntypes.

(2) In 1813 De Candolle segregated the genus *Cajanus* (Tribus *Phaseoleae*) from *Cytisus* L. (Tribus *Loteae*). The main differences between these two genera are

Cytisus L.	*Cajanus* DC.
(1) stipels absent	stipels present[6]
(2) eglandular	glandular
(3) bracteoles present	bracteoles absent
(4) calyx tubular with pronounced upper and lower lip giving it a bilabiate appearance	calyx campanulate with 5 subequal lobes
(5) stamens monadelphous (DC.)	stamens diadelphous (DC.)
(6) anthers dimorphic	anthers equal
(7) pods without dissepiments between seeds (DC.)	pods with (lacerate) dissepiments between most seeds (DC.)
(8) cotyledons rather flat, during germination developing into leaves with stomata (DC.)	cotyledons thick, not changing during germination, remaining succulent without stomata (DC.)

(3) De Candolle (1813) differentiated between *C. bicolor* (syn. *Cytisus pseudocajan* Jacq.) with discolourous standard and 4–5-seeded pods, and *C. flavus* (syn. *Cytisus cajan* L.) with concolourous standard and 2–3-seeded pods. Purseglove (1968) mentions both species as varieties of *Cajanus cajan* with the following characteristics:
(a) var. *flavus* (DC.) Purseglove ?: short, early maturing plants; standard yellow; pod glabrous, green (light coloured when mature), usually 3-seeded;
(b) var. *bicolor* (DC.) Purseglove ?: large, bushy, perennial, late-maturing plants; standard yellow with abaxial side red or purple or streaked with these colours; pod hairy, blotched with brown or dark coloured, 4–5-seeded, darker coloured or speckled when mature.

These characteristics used in distinguishing between the two taxa at the variety-level are questionable, according to Purseglove, since many of these characteristics (for

6. According to Hutchinson (1964) *Cajanus* DC. is exstipellate, which is incorrect (see e.g. Amshoff, 1939).

instance colour of the flower) follow Mendelian inheritance and are distributed in both varieties. In the Ethiopian area insufficient evidence is available to maintain these 'varieties'; cultivars may be segregated.

(4) The following seed types were found in Ethiopia.

(a) Seeds grey with some small red-brown spots. I designate this taxon as cv. Duke of Harar (based on WP 3512 and WP 8630).

(b) Seeds grey with marked irregular red-brown spots. I designate this taxon as cv. Konso Delight (based on WP 3225A).

(5) The following differences were found between plants raised at Wageningen and in Ethiopia.

	Wageningen	Ethiopia
petiole	1.5 – 8.0 cm	1.0 – 3.5 cm
rachis	0.5 – 3.0 cm	0.8 – 2.0 cm
leaflet: length	5.0 – 13.5 cm	4.5 – 12.0 cm
width	2.5 – 6.5 cm	1.5 – 4.5 cm
peduncle	0.5 – 4.0 cm	1.5 – 5.0 cm
length of first (single) leaf	3.5 – 8.0 cm	4.0 – 6.5 cm

(6) The description is based on the following specimens.

Shoa	20 km past Nazret on Asella road, in fruit garden of Awash Melka Saa: WP 1527.
Gamu Gofa	54 km past Gidole on Konso track: WP 3215; Giarso market: WP 3224E, WP 3224F, WP 3225A, WP 3226i.
Sidamo	11 km past Shashamane on road into Wondo valley: WP 2623.
Hararge	Hirna, in coffee plantation: F. G. Meyer 8733; 0.5 km past College entrance to Alemaya, in garden: WP 706; garden Alemaya: WP 1837; Hamaressa, along the highway (in garden?): Taddesse Ebba 517; garden Harar: WP 3512, WP 4008.
Grown at Wageningen	WP 6131, WP 6132, WP 7527–WP 7530, WP 8602, WP 8630, WP 8631, WP 8672.

Ecology

This pulse is particularly drought resistant due to its deep[7] root system which permits good growth under semi-arid conditions with less than about 600 mm rain per year, when other crops fail to yield satisfactorily. The plant will thrive in regions with an annual rainfall even exceeding 2500 mm and also under heavy irrigation, provided there is no stagnant water on the ground, even for a few days. It is less suitable for the more humid tropics. Most cultivars are very sensitive to night frost. In India the highest altitude at which it is recorded to produce mature seeds is ± 2000 m and then only in well-sheltered localities. This also holds for Ethiopia. In general the high-

7. No information has been found in literature concerning the depth of the root system.

altitude cultivars are early maturing annuals in which seeds mature in rather short growing seasons so that they are able to escape cold weather and night frost. It may be grown on almost all soil types, provided the soil is not markedly deficient in lime but it does not tolerate water-logging. Most cultivars, notably the tall, late-maturing ones, are short-day plants. This affects the time of maturity and the height of the plant and therefore the ease of harvesting (Pathak, in: Kachroo, 1970; Purseglove, 1968).

In Ethiopia the crop is grown as a field crop in the Konso area (between about 1700 m and 1900 m) which has an average annual rainfall of 600–800 mm. It has rarely been found elsewhere. Only in Hararge it has been observed a few times as a garden crop.

Husbandry

In India and Africa the crop is often grown in mixed cultivation with sorghum, finger millet, bulrush millet, maize, sesame or other crops. The seed is either broadcast or sown in one row to every 3–5 rows of the main crop. In such cases the main crop is harvested first, after which the pigeon peas continue to grow and are harvested later (Purseglove, 1968).

In India it is planted at the beginning of the wet season, late in June or July. It becomes well established but shows little growth for months. The tillage operations used for the main crop sorghum serve at the same time for the legume. The sorghum develops well, shades the ground and reduces weed growth; when the sorghum is cut in 'winter' the pigeon pea is able to continue its growth and to mature some months later. According to Pathak (1970), pigeon pea develops numerous root nodules when grown on well-tilled and well-drained soils, especially during its earlier growth stages.

On Mauritius and in Uganda the crop plays a more important role in agriculture than elsewhere in Africa. It is generally planted towards the end of a rotation as a restaurative crop, the cycle being, for example, maize-groundnut-tobacco-pigeon pea (3–4 years). In Uganda it is intercropped with finger millet, in Malawi with maize (Stanton et al., 1966).

When well-developed, the crop will suppress most weeds, and this is aided by the dry season leaf-fall. But its slow early growth makes weeding necessary. Moreover the crop is easily smothered by many other crops when grown in mixtures; intercropped rows are thus preferable to broadcast mixtures (Gooding, 1962).

When grown in pure stands, spacing depends on the purpose for which the crop is grown, the cultivar, and the required size of the mature plant. In pure stands, spacing varies from 0.9 to 1.8 m between the rows and 0.3 to 1.2 m in the rows. When grown as green manure, cover or fodder crop, broadcasting is customary and a higher seed rate is required (Purseglove, 1968).

The late-maturing cultivars take 8–12 months to reach maturity, whereas the early types require 5–6 months. The tall, late-maturing cultivars, being short-day plants, have a limited planting season (for Trinidad early November to late February). The dwarf, early-maturing cultivars may not be affected by the photoperiod and can

yield all the year round. The crop can be continued for 3–4 years, or may be ratooned, as is done when grown for green manure or fodder. As a pulse crop the yields usually decline after the first year so that it is best to treat the crop as an annual (Purseglove, 1968).

In India and Burma it is usual to harvest the whole plants, which are then dried and threshed. A few plants are often grown near homesteads for green pods (Purseglove, 1968). For Africa Stanton et al. (1966) report that, after harvest, the plants are cut back to 25 cm, and the regrowth may be browsed by cattle, though when too old it causes irritation of the rumen. The pods shatter when dry and therefore the final drying must be done after harvest.

In pure stands the yield of green pods varies between 1100 and 4500 kg/ha, that of the dried seeds between 560 and 1100 kg/ha. In mixed cultivation yields of 225–900 kg/ha are obtained (Purseglove, 1968).

In the Konso region of Ethiopia, pigeon pea is sown mixed with other crops at the onset of the main rains, begin March. The small, terraced fields are manured and irrigated (Kuls, 1958). As a rule all beans and peas are harvested around August, but pigeon peas were observed on fields as late as February. It is cultivated here as an annual crop in this region.

Uses

Young leaves, young shoots, young pods and young and ripe seeds are eaten. The young leaves, shoots and pods may be eaten either raw or boiled. The young green seeds are consumed as a vegetable in many countries. In Puerto Rico and Trinidad they are canned. The ripe dry seeds are boiled and eaten; in India they are split ('dhal'), boiled, and eaten as a vegetable or in soup; the dried husks, seeds and broken dhal are used as a cattle feed; the ripe seeds may be used for making taogé (bean sprouts). According to Aykroyd & Doughty (1964) the seed has an acrid taste, mainly due to the seed coat, which is difficult to remove.

The green parts of the plant provide excellent fodder, and also hay and silage. Pigeon peas may be planted alone or in pastures as browse plants. The dry stems are used as fuel and for thatching. The plant is often grown as a dividing hedge between plots.

In addition it may serve as a cover crop, windbreak and green manure or for temporarily shading young cocoa and other crops. It is especially useful to improve the soil and to protect it against erosion.

According to Burkill (1966), the seeds have a soporific effect when eaten raw in quantities, but they seem to do no harm to the body. In India, Indonesia and Malaysia the leaves are used for medicinal purposes.

In Ethiopia, particularly in Konso, ripe seeds are eaten cooked.

Protein content

Leaves: ca 9% (Terra, 1966); young pods: 7–10% (Terra, 1966); young seeds: ca 7% (Terra, 1966; Purseglove, 1968); ripe seeds: 20–22% (Terra, 1966), 19.2% (Purseglove, 1968).

The first limiting amino acids are methionine and cystine, followed by tryptophan (Aykroyd & Doughty, 1964).

(2) Canavalia ensiformis (L.) DC. Fig. 3; Plate 2

'*Canavalia*': latinized derivation of 'canavaly', a Malabar vernacular plant name.
'*ensiformis*': from Lat. ensis = sword and forma = shape, so meaning sword-shaped; pod sword-shaped.

De Candolle, Prodr. 2: p. 404 (1825).
Type: Habitat in Jamaica; '*Phaseolus* maximus, siliqua ensiformi nervis insignita & semine albo, membranula incluso'; Sloane hist. 1: p. 177, t. 114, f. 1, 2, 4 (1707) (lecto.!).

Synonyms

Dolichos ensiformis L., Sp. Pl. ed. 1: p. 725-726 (1753) (basionym).
Dolichos acinaciformis Jacq., Coll. Bot. 1: p. 114 (1786).
Malochia ensiformis (L.) Savi, Nuovo G. Lett. Pisa 10: p. 21 (1825).
Canavalia gladiata (Jacq.) DC. var. *ensiformis* (L.) Benth., in: Flora Bras. 15(1): p. 178 (1859-1862).

Literature

1925: Piper, Contr. U.S. natn. Herb. 20(14): p. 567. (tax.)
1931: Ochse, Indische groenten: p. 373-375. (agric.)
1937: Dittmer, in: Vavilov & Wulff, eds, Koultournaja Flora SSSR 4: p. 424-426. (tax.)
1946: Robyns & Boutique, Bull. Jard. bot. État Brux. 18(1-2): p. 71-72. (tax.)
1954: Robyns, Flore Congo Belge 6: p. 145-147. (tax.)
1955: Cufodontis, Enumeratio, Bull. Jard. bot. État Brux. 25(3): p. 319-320. (tax.)
1955: Dalziel, The useful plants of West Tropical Africa: p. 234. (agric.)
1958: Dandy, The Sloane Herbarium: p. 204. (tax.)
1959: Mansfeld, Vorläufiges Verzeichnis, Die Kulturpflanze, Beiheft 2: p. 205. (tax.)
1959: Whyte et al., Legumes in agriculture: p. 258-259. (agric.)
1963: Backer & Bakhuizen van den Brink, Flora of Java 1: p. 633-634. (tax.)
1964: Aykroyd & Doughty, Legumes in human nutrition: p. 102, 117. (agric.)
1964: Sauer, Brittonia 16: p. 142-144. (tax.)
1965: Busson, Plantes alimentaires de l'ouest africain: p. 236-239, 252. (agric.)
1966: Burkill, Dict. ec. prod. Malay Peninsula 1: p. 437-438. (agric.)
1966: Stanton et al., Grain legumes in Africa: p. 93. (agric.)
1966: Terra, Tropical vegetables: p. 34. (agric.)
1968: Purseglove, Trop. Crops, Dicotyl. 1: p. 242-245. (agric.)
1971: Verdcourt, in: Flora Trop. East Africa, Leg. 4, Papil. 2: p. 572. (tax.)

Local names: dir-daguer, saar-sar (Somali).
Trade names: Jack bean, horse bean (English); pois sabre, haricot sabre (French).

Geographic distribution

It is a native of the West Indies and adjacent parts of America and has been discovered at archaeological sites in Mexico dated 3000 B.C. It is now cultivated throughout the tropics. It was described from Jamaica, but subsequently for a long time was held by botanists to be identical with the sword bean, *Canavalia gladiata* (Jacq.) DC. (Burkill, 1966). The latter is fairly extensively cultivated throughout south-eastern Asia, particularly India, and has now spread throughout the tropics (Purseglove, 1968).

C. ensiformis is recorded to be found in south-west Ethiopia, Gojam, Wollo and Tigre, as well as in the Ogaden and Somalia (Cufodontis, 1955). Meyer collected 1 specimen near Welkite in Shoa (1962).

C. gladiata is recorded for Shoa, the Ogaden and Somalia (Cufodontis, 1955).

Description

A bushy, erect–spreading, (slightly) white-appressed pubescent annual, capable of becoming a perennial climber, with tips of branches tending to twine particularly in shade.

Stems terete, slightly ribbed, sometimes hollow, older stems ± glabrous.

Stipulae very small, ± triangular, appendaged, with sometimes a black spot at the place of attachment, top part becoming brown and often deciduous, with appendage becoming thicker, slightly pubescent.

Leaves alternate, 3-foliolate. Petiole ca 11–17 cm long, grooved above, slightly pubescent; pulvinus thick, sometimes ribbed, with denser indumentum, dark green. Rachis ca 3–4.5 cm long, grooved above, slightly pubescent, topped by a leaflet.

Leaflets: First two leaflets opposite, top leaflet sometimes slightly larger or smaller, with petiolule up to 8 mm long and slightly grooved above with indumentum denser than on petiole, ovate–elliptic, 9–14 × 5–8 cm, entire, ± cuneate at base, acute or rounded and mucronate at top, green, with prominent venation beneath, thinly pubescent–glabrescent.

Stipellae minute, 1 per lateral leaflet, 2 per top leaflet.

Inflorescence an axillary raceme with several flowers. Peduncle up to ca 30 cm long. Rachis up to ca 20 cm long, tuberculate; flowers arising 1–3 together; bracts probably 1 per flower and early deciduous; each group of flowers probably subtended by an early deciduous bract; flowers shortly pedicelled with two small bracteoles attached at the base of the calyx. Bracteoles early deciduous, obtuse.

Calyx campanulate, sparsely pubescent; tube 6–10 mm long; lobes 5, the upper pair of lobes connate forming a truncate lip, ca 5–8 mm long, the other 3 lobes small.

Corolla: Standard rounded, ca 2.7 cm long, reflexed, bi-auriculate, with auricles inflexed, with two callosities above the claw, emarginate at top, glabrous, at first pink with white veins, afterwards approaching to violet. Wings glabrous. Keel with top obtuse–rounded, glabrous.

Androecium: Stamens monadelphous, joined into a closed tube. Vexillary stamen

free at base. Anthers uniform, globose, dorsifixed, yellow.

Disk ?

Gynoecium: Ovary stalked, many-ovuled. Style curved, slender, glabrous ? Stigma terminal.

Pod oblong, laterally compressed, up to ca 33 × ca 3 cm, stalked, beaked, flattened dorsally, with on each valve a sutural rib and another prominent parallel rib just below it and the pair of ribs sometimes connected by some oblique veins near the top of the pod, slightly pubescent, with pod wall striate, ca 10–20-seeded; seeds separated by various amounts of intermediate (sept-like) tissue.

Seeds oblong, laterally compressed, ca 20 × 15 mm, white. Hilum oblong, ca 8 mm long (less than half of the length of the seed), brown, surrounded by an orange-brown line. Cotyledons pale yellow.

Seedling not available.

Note

The description is based only on the specimen of Meyer 8095, which consists of a branch with leaves, one fruit and some mature seeds. Consequently the botanical description is very incomplete, since other specimens collected in Ethiopia are not known. In supplementing the description of this taxon Backer & Bakhuizen van den Brink (1963), Purseglove (1968) and Verdcourt (1971) have been used.

Taxonomic notes

(1) In Sp. Pl. ed. 1 Linnaeus refers to Hort. Ups. p. 360, but no taxon has been described in the Hort. Ups. that might have stood for *Dolichos ensiformis*. However, in Hort. Cliff. p. 360 a diagnosis and a description are given of *Dolichos ensiformis*. There is no specimen in the Clifford Herbarium or in LINN.

Linnaeus quoted several sources of which Sloane is the most important, since Linnaeus refers to a plate in Sloane's 'A voyage to the islands Madera ... and Jamaica ...'. In the Sloane Herbarium a specimen of *Dolichos ensiformis* is present (vol. 3: p. 67). The sheet carries a label saying '*Phaseolus* maximus, siliqua ensiformi nervis insignata, & semine albo membranula incluso. Cat. Jam. p. 68. hist. 177. Ray. hist. t. 3. p. 441'. Opposite the herbarium specimen (on the verso of p. 66) a drawing is present, made by Everhardus Kickius. It shows a large pod, an opened pod and next to it two seeds. Apparently the opened pod has been present on the herbarium sheet (p. 67), but is missing now; only the outline is still clearly visible (with brown discolouration and slightly impressed) and it is of the same size as the opened pod on the drawing. The same is true for the large pod of which only a small piece survived on the herbarium sheet. The seeds are missing. In between the two described pods another smaller pod is present on the sheet, but it is lacking on the drawing. Possibly this element has been added later on.

According to Dandy (1958), from the drawings of Kickius the copper plates engraved by M. van der Gucht were prepared illustrating Sloane's History. Dandy (l.c. p. 204) underlined the importance of the drawings and descriptions in Sloane's book,

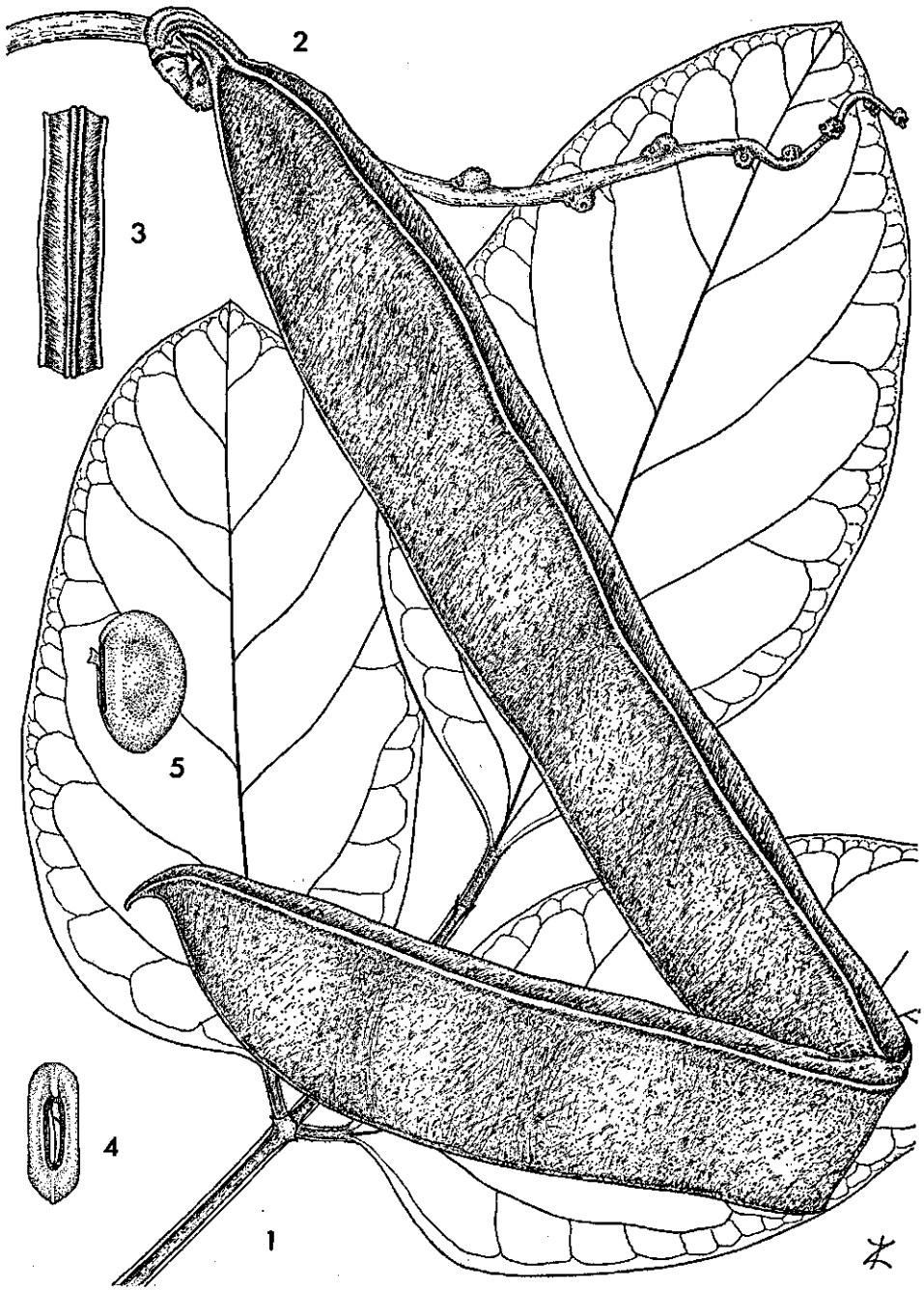

Fig. 3. *Canavalia ensiformis* (L.) DC. cv. Welkite Treasure. – 1. leaf (5/6×); 2. pod, artificially bent (5/6×); 3. pod, detail of dorsal suture (5/6×); 4. seed, with hilum (5/6×); 5. seed, lateral view (5/6×). – 1. Meyer 8095; 2. Meyer 8095 and WP 8694 (for the rachis); 3–5. Meyer 8095.

since they were frequently cited by Linnaeus and other early authors in founding species. At the time Linnaeus included *Dolichos ensiformis* in his Sp. Pl. ed. 1, he used the description and the plate of this taxon as found in Sloane's History (1707). Although Linnaeus consulted Sloane's Herbarium (see preface Sp. Pl. ed. 1), he also referred to the drawing in Sloane's History. Consequently, the choice of Verdcourt (1971), who designated the specimen in the Sloane Herb. (vol. 3: p. 67) as the holotype of *Canavalia ensiformis*, has to be rejected, and I follow Sauer (1964) who designated as the lectotype of *Canavalia ensiformis* (L.) DC. plate 114, f. 1, 2, 3 of Sloane's History 1. The specimen in the Sloane Herbarium (vol. 3: p. 67) can be considered as the typotype of the taxon involved (see Stearn, Facs. ed. Sp. Pl. ed. 1, 1, Introduction: p. 128 (1959)).

(2) See for the affinities between *C. ensiformis*, *C. gladiata* and *C. virosa* under *Canavalia virosa* taxonomic note 2 (p. 82).

(3) I designate this taxon as cv. Welkite Treasure (based on F. G. Meyer 8095).

(4) The description is based on the following specimen.

Shoa near Welkite in *Coffea arabica* L. plantation: F. G. Meyer 8095.

Ecology

It is deep-rooted[8], hardy, drought-resistant and will tolerate shade (Purseglove, 1968). It is being grown mainly in the lowlands, but reaches at least 1800 m elevation. The plants are usually grown as bushy annuals, but they are capable of vining and perennial growth under favourable conditions (Sauer, 1964). Once established the plants withstand very dry conditions (Stanton et al., 1966).

Husbandry

Canavalia ensiformis is easy to grow and suitable for compounds. The bushy form is grown spaced at 1–1.5 m by 1 m, and after 3–4 months the first young pods may be harvested (Terra, 1966). It is established as a green manure crop by broadcasting at a seed rate of 54–70 kg/ha. The yield of green matter is 40–50 ton/ha and that of the dried beans 1350 kg/ha (Purseglove, 1968).

Uses

The crop is grown for the leaves, top shoots, young pods and both young and mature seeds. Even when using the mature, white seeds, it is advisable to renew the cooking water once, whereas with coloured seeds even more care should be taken (Terra, 1966). The fresh, unripe seeds are reputed to be poisonous, but there seems little foundation for this belief. The mature seeds have a tough, thick skin, and prolonged soaking and

8. No information has been found in literature on the depth of the root system.

boiling with changes of water are needed to soften it. The cooked seed has a coarse, mealy texture and little flavour. This legume is regarded as inferior food by some people, because of its unattractive texture and flavour and because it is also used as fodder (Aykroyd & Doughty, 1964). Stanton et al., (1966) reported that in Africa, in times of scarcity, the seeds are sometimes eaten after long cooking. In Java both flowers and young leaves are steamed and used as a flavouring (Ochse, 1931). It is grown as a green manure and cover crop. As a fresh fodder livestock eat it with reluctance, it is more palatable when dry (Purseglove, 1968).

The closely related *C. gladiata* is used as green manure, a cover crop and for forage. In tropical Asia the young pods and seeds are extensively used as a vegetable, but to a lesser extent elsewhere. The mature seeds should be eaten with caution as they may be poisonous (Purseglove, 1968), but after preparations like boiling (with salt), rinsing in running water, fermentation they seem to be edible (Terra, 1966). In Java flowers and young leaves are steamed and used as a flavouring (Ochse, 1931); in Zaire the leaves are eaten with fish as a condiment (Robyns, 1954). Ochse described the preparation of the seeds for food in Java thus: they are twice boiled for a long time and the water of the first boiling is thrown away. When the seeds are soft, they are left in running water for two days after removal of their skin; then they are fermented for 3–4 days, cooked once more, and eaten as a flavouring.

In Ethiopia the pods of *C. ensiformis* are used as a vegetable.

Protein content

Leaves and young pods: 2–7(–9)% (Terra, 1966; Purseglove, 1968); ripe dried seeds: 22% (Terra, 1966), 23.4% (Purseglove, 1968), 25% (Busson, 1965).

(3) Canavalia virosa (Roxb.) Wight & Arnott

Fig. 4, 5; Plate 3

'*Canavalia*': see under *Canavalia ensiformis*.
'*virosa*': from Lat. virus = poison, venom; thus venomous, poisonous, causing harm.

Wight, Prodr. Fl. Pen. Ind. Or. 1: p. 253 (1834).
Type: India; Roxburgh drawing 2085 (K, lecto.!).

Synonyms

Dolichos polystachios Forsk., Fl. Aegypt.-Arab.: p. 134 (1775), non L.
Dolichos virosus Roxb., Fl. Indica 3, ed. Carey: p. 301 (1832) (basionym).
Canavalia polystachia (Forsk.) Schwfth, Reliq. Kotsch: p. 25, t. 20, 21 (1868).
Canavalia ensiformis (L.) DC. var. *virosa* (Roxb.) Baker, in: Hooker, Fl. Br. India 2: p. 196 (1872).
Canavalia africana Dunn, in: Piper & Dunn, Bull. misc. Inf. R. bot. Gdns Kew: p. 135 (1922).
Canavalia gladiata (Jacq.) DC. var. *virosa* (Roxb.) Chiov. (1930): vide Cufodontis (1955).

Literature

1922: Piper & Dunn, Bull. misc. Inf. R. bot. Gdns Kew: p. 136. (tax.)
1925: Piper, Contr. U.S. natn. Herb. 20(14): p. 557, 572. (tax.)

1946: Robyns & Boutique, Bull. Jard. bot. État Brux. 18(1-2): p. 76-77. (tax.)
1955: Cufodontis, Enumeratio, Bull. Jard. bot. État Brux. 25(3): p. 321. (tax.)
1956: Sealy, Kew Bull. 1956, 2: p. 297-304, 334. (tax.)
1959: Mansfeld, Vorläufiges Verzeichnis, Die Kulturpflanze, Beiheft 2: p. 205. (tax.)
1963: Backer & Bakhuizen van den Brink, Flora of Java 1: p. 633. (tax.)
1964: Sauer, Brittonia 16: p. 152, 154. (tax.)
1971: Verdcourt, in: Flora Trop. East Africa, Leg. (4), Papil. (2): p. 573-574. (tax.)

Local name(s): sjef (Arabic); ged sav (Somali?).
Trade name(s): ?

Geographic distribution

Widespread in tropical Africa from Angola, north-east South Africa and West Africa to south Arabia, Socotra and India. Possibly *C. gladiata* (Jacq.) DC. is a cultural form of this taxon (Piper, 1925; Cufodontis, 1955; Backer & Bakhuizen van den Brink, 1963). It is occasionally cultivated.

For Ethiopia found in possibly recent cultivation. It is recorded as wild for Eritrea (Cufodontis, 1955).

Description

A climbing, (slightly) white-appressed pubescent annual or perennial.

Stems terete, slightly ribbed, sometimes hollow, older stems slightly pubescent.

Stipulae very small, triangular, ca 3 mm long, acuminate at top, appendaged, with a black spot at the place of attachment, with top part becoming brown and often deciduous, with appendage becoming thicker, pubescent.

Leaves alternate, 3-foliolate. Petiole (2.5–)3.5–5.0(–9.5) cm long, grooved above, slightly pubescent; pulvinus thick, sometimes ribbed, with denser indumentum, dark green. Rachis (1.0–)1.5–2.0(–2.5) cm long, grooved above, slightly pubescent, topped by a leaflet.

Leaflets: First 2 leaflets opposite, top leaflet slightly larger, with petiolule short (ca 5 mm long) and grooved above with indumentum denser than on petiole, ovate–elliptic, (5.5–)6.0–8.0(–10.5) × (3.5–)4.5–6.0(–7.0) cm, entire, broadly rounded at base, as a rule obliquely acuminate and with a twist at top and mucronate as well, green, lighter green with prominent venation beneath, slightly pubescent.

Stipellae nearly always absent.

Inflorescence an axillary raceme with several flowers. Peduncle ca 18 cm long, flattening towards the top, hollow, slightly pubescent. Rachis ca 5 cm long, laterally compressed, pubescent, tuberculate; flowers arising 1–3 together; bracts 1 per flower, early deciduous, minute, saccate, with edge ciliate; each group of flowers subtended by a minute, early deciduous bract, saccate, slightly pubescent; flowers shortly pedicelled, with two small bracteoles attached at the base of the calyx. Bracteoles early deciduous, minute, saccate, slightly pubescent.

Calyx campanulate, prominently veined, fleshy, pubescent; tube gibbous dorsally,

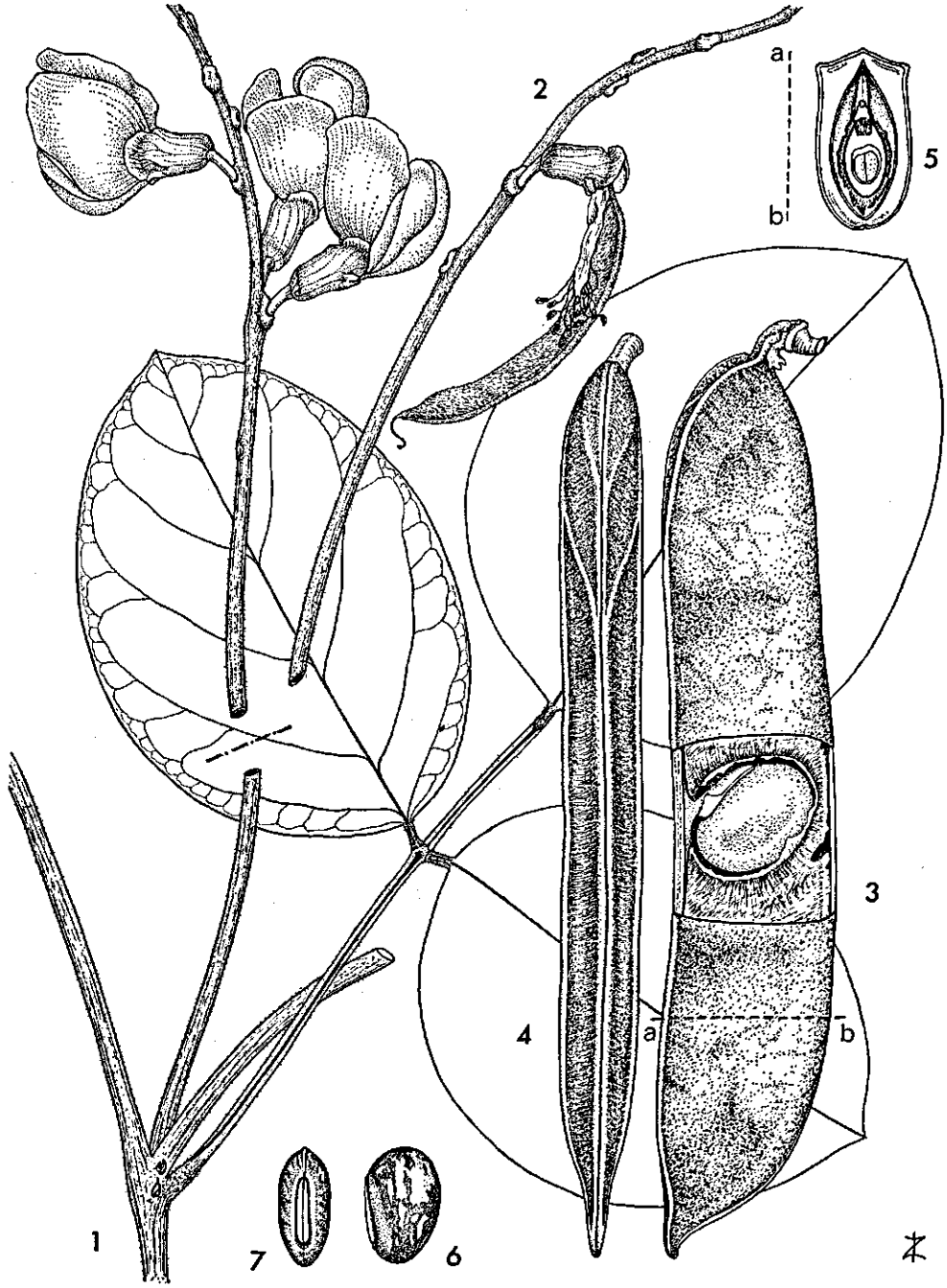

Fig. 4. *Canavalia virosa* (Roxb.) Wight & Arnott cv. Werer Beauty. – 1. branch with leaf and inflorescence (5/6 ×); 2. inflorescence with a young pod (5/6 ×); 3. pod, lateral view (5/6 ×); 4. pod, dorsal view (5/6 ×); 5. transverse section of pod (5/6 ×); 6. seed, lateral view (5/6 ×); 7. seed, with hilum (5/6 ×). – 1. WP 8676 (including spirit mat.); 2. WP 8676; 3–5. WP 4943 (spirit mat.); 6–7. WP 4943.

ca 7 mm long; lobes 5, the upper pair of lobes connate forming a bilobed lip, ca 6 mm long, the other three lobes ± equal, broad, rounded, ca 3 mm long.

Corolla: Standard veined, with lower part directed forward, upper part erect above a deep sinus, hood-shaped, obovate, ca 30 × 25 mm, with longitudinal edges reflexed when older, with claw long and narrow, bi-auriculate, with auricles inflexed, with two longitudinal prominent projecting callosities separated by a channel, emarginate at top, glabrous, bright light purple (turning blue-violet), with a yellow spot right above the callosities, becoming white and radiating further upwards. Wings furrow-shaped near the base, narrowly obovate, ca 28 × ca 7 mm, clawed, auriculate, with auricles fleshy and entering the cavity below the appendages of the standard, 'pocketed', rounded at top, glabrous, bright light purple (turning blue-violet), adherent to the keel. Keel ladle-shaped, ca 25 × ca 8 mm, clawed, auriculate, entirely split dorsally, ventrally split near the base, rounded at top, pale purple (turning pale blue-violet).

Androecium: Stamens monadelphous, joined into a closed tube. Vexillary stamen free at base. Tube slightly curving, ca 20 mm long when the filament of the vexillary stamen is released; this is followed at ± regular intervals on either side by the remaining stamens; free part of filaments winged, alternately longer and shorter, ca 4–8 mm long. Anthers ellipsoid, ca 2 mm long, dorsifixed, orange-yellow.

Disk annular, ribbed, repandous.

Gynoecium: Ovary stalked, ca 21 mm long, slender, laterally compressed, slightly curving, appressed silky-pubescent, ca 7-ovulate, basal and apical parts sterile. Style sharply upturned, laterally compressed, ca 6 mm long, with longer hairs abaxially. Stigma terminal, capitate, glandular.

Pod oblong, laterally compressed, ca (9–)13(–15) × ca 3 cm, flattened dorsally, with on each valve a sutural rib and another prominent parallel rib, with the pair of ribs connected by one or more oblique veins near the base of the pod, pubescent, with pod wall slightly striate, ca 2–6-seeded; seeds separated by various amounts of intermediate (sept-like) tissue.

Seeds oblong, ± laterally compressed, ca 15–20 × 9–13 mm long, light yellowish-brown with darker coloured stripes. Hilum oblong, ca 7–11 mm long (more than half the length of the seed), dark brown, surrounded by a dark brown line. Seed coat very hard. Cotyledons pale yellow.

Seedling with epigeal germination. Root system well-developed. Cotyledons obovate, thick. Hypo- and epicotyl glabrescent. First two leaves simple, cordate, ca 3.0–5.5 × 3.0–6.0 cm, rounded at top, slightly pubescent. Stipules of the two leaves connate. Petiole ca 1.5–4.0 cm long, grooved above, glabrescent. Stipellae absent.

Notes

1. The description is based on only two samples.
2. Plants raised in the greenhouse at Wageningen under long-day circumstances produced luxurious vegetative growth but did not flower. Under short-day (11 hours) plants flowered and set fruit.

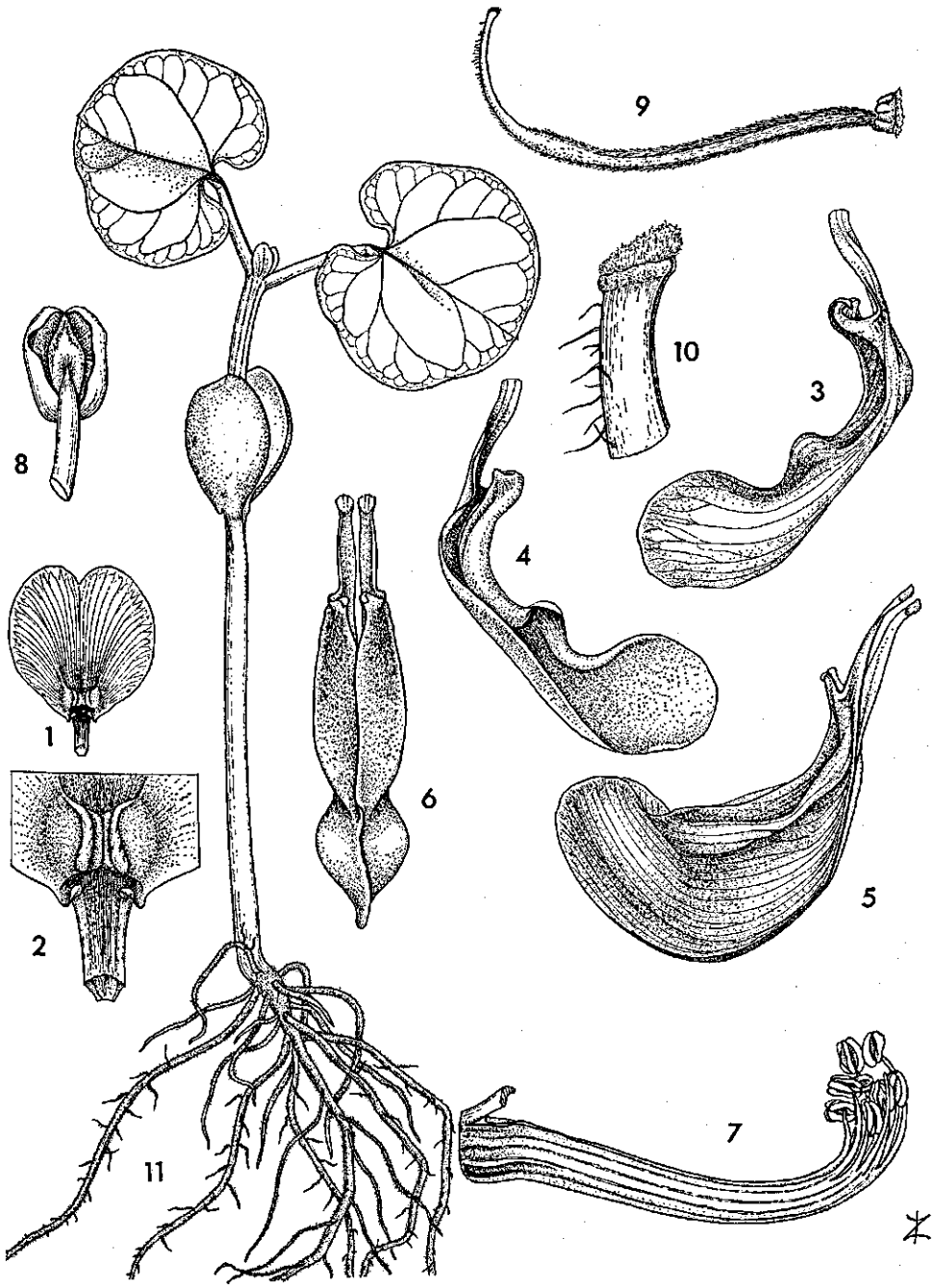

Fig. 5. *Canavalia virosa* (Roxb.) Wight & Arnott cv. Werer Beauty. – 1. standard, adaxial view (5/6×); 2. standard, detail of basal adaxial part (2½×); 3. wing, abaxial view (2½×); 4. wing, adaxial view (2½×); 5. keel, lateral view (2½×); 6. keel, dorsal view (2½×); 7. staminal sheath (2½×); 8. anther (2½×); 9. pistil (2½×); 10. stigma (15×); 11. seedling (5/6×). – 1–10. WP 8676 (including spirit mat.); 11. WP 8643 (spirit mat.).

Husbandry

In Ethiopia the plant is grown along walls or fences.

Uses

The young pods and seeds are used as a vegetable (Mansfeld, 1959). The seeds are poisonous and may only be eaten after various kinds of preparations like boiling, rinsing in running water and fermentation, as is done with seeds of *C. gladiata* and *C. ensiformis*. Occasionally it is cultivated as a cover crop (Sauer, 1964).

For Ethiopia the use of seeds is recorded (Taddesse Ebba, 1968).

Protein content

No information available.

(4) Cicer arietinum L. **(2n = 16)** **Fig. 6; Plates 4-8**

'*Cicer*': derived from the ancient Latin plant name 'cicer' (probably of Greek origin 'krios'), which was used, very probably, for what is now commonly known as 'Cicer'. Cf. Cicero, a well-known Roman family name.
'*arietinum*': referring to Latin 'aries', a ram, which points to the shape of the seed resembling a ram's head.

Linnaeus, Sp. Pl. ed. 1: p. 738 (1753).
Type: from southern Europe; '*Cicer* foliolis serratis' (BM,Hort. Cliff., lecto.!).

Synonyms

Cicer grossum Salisb., Prodr.: p. 340 (1796).
Cicer sativum Schkuhr, Bot. Handb. 2: p. 367, t. 202 (1805).
Cicer physodes Reichb., Fl. Germ. Excurs.: p. 532 (1830).
Cicer rotundum Jord. ex Alef., Oest. bot. Z. 9-11: p. 356 (1859).

Literature

1928-1929: Popov, Bull. appl. Bot. Genet. Pl. Breed. 21(1): p. 1-254. (tax.)
1937: Popova, in: Vavilov & Wulff, eds, Koultournaja Flora SSSR 4: p. 43-46. (tax.)
1955: Cufodontis, Enumeratio, Bull. Jard. bot. État. Brux. 25(2): p. 306. (tax.)
1957: Kuls, Petermanns geogr. Mitt. 101: p. 248-249. (agric.)
1960: Simoons, Northwest Ethiopia, Peoples and economy: p. 71. (agric.)
1964: Aykroyd & Doughty, Legumes in human nutrition: p. 117. (agric.)
1968: Purseglove, Tropical Crops, Dicotyl. 1: p. 246-250. (tax. + agric.)
1971: Verdcourt, in: Flora Trop. East Africa, Leg. 4, Papil. 2: p. 1065-1067. (tax.)
1972: Maesen, van der, Cicer L. Meded. LandbHogesch. Wageningen 72(10): p. 30-35, 131-136 (tax.), p. 137-298. (agric.)

Local names: ater, ater-cajeh (Tigre, Tigrinia); atir (Saho); shihu, shimbera, shumbra (Amarinia, Gallinia).
Trade names: chickpea, Egyptian pea, Bengal gram, gram (English); pois chiche (French).

Geographic distribution

Cicer arietinum is not known in a wild state, but in some regions is found as an escape. It is of ancient origin, probably from western Asia or southern Europe, and has been cultivated for centuries in the Middle East, India, the Mediterranean and Ethiopia. The crop was known to the ancient Egyptians, Hebrews and Greeks (Purseglove, 1968). It is cultivated extensively in India and the Middle East during the colder period of the year. Recently it has been introduced to tropical Africa, Central and South America and Australia, but is of little importance there. Chickpea is the most important pulse crop of the Middle East, India, and Ethiopia.

In Ethiopia it is widely grown, mostly for the local market. The main production areas are northern and central Ethiopia, but small plots may also be found elsewhere. It is present at nearly every market.

Description

An erect, few-branched, glandular-pubescent, grey-green annual. Taproot well-developed.[9]

Stems slightly angular, ribbed, with few basal branches, arching at top.

Stipulae widely variable in shape, with more than one main nerve, in young plants more or less ovate, later more or less obliquely triangular and with 1–4 long, acute teeth.

Leaves alternate, pinnate, with (8–)11–13(–15) leaflets; petiole grooved above, short; rachis (3.5–)5–7(–8) cm long, grooved above, ending in a mucro or a sometimes reduced leaflet.

Leaflets opposite, or alternate, subsessile, elliptic, ovate or obovate, top leaflet sometimes obtriangular or rhomboid, (10–)15(–20) × (3–)5–7(–9) mm, cuneate at base, acute at top, at edge near base entire, near top acutely dentate.

Stipellae absent.

Inflorescence an axillary raceme (1 flower); peduncle slender, (0.8–)1.0–2.5(–3.7) cm long; rachis ending into a filiform apex; bracts 1–3 (if 3, then forming a tri-dentate scale); pedicel sharply bent when bearing pod, (0.8–)1.0–1.5(–1.7) cm long, sometimes purple, in contrast with the green peduncle.

Calyx campanulate; tube gibbous dorsally, ca 3 mm long; lobes 5, subequal, narrowly triangular, ca 5 mm long.

Corolla small, not glandular-pubescent, erect and widely spreading. Standard broadly obovate, ca 10 × ca 9 mm, clawed, obcordate and mucronate at top, red-purple, white with red-purple streaks, or white. Wings obovate, ca 8 × ca 4 mm, clawed, auriculate, 'pocketed', with abaxially glandular hairlets near the 'pocket' and the nearby margin, obtuse at top, red-purple (turning purple-violet), or white. Keel

9. According to Van der Maesen (1972) chickpea is a deep rooting species (1–2 m).

boat-shaped, ca 7 × ca 3 mm, clawed, partly split dorsally, ventrally split near the base, bi-auriculate, bi-'pocketed', white.

Androecium: Stamens diadelphous (9 + 1). Vexillary stamen free, ca 6 mm long, winged, with apical part slightly broadering, flat. Staminal sheath ca 4 mm long when on either side the first filament is released; it is followed by 3 single stamens and then ending by the top stamen; filaments winged; top of filaments slightly broadering, flat. Anthers ellipsoid, ca 0.5 mm long, alternately basi- and dorsifixed, light yellow.

Disk annular.

Gynoecium: Ovary subsessile, ca 2 mm long, glandular-pubescent, 2(–4)-ovulate. Style upturned, ca 4 mm long, filiform or nearly so, at base pubescent, otherwise glabrous. Stigma: the slightly swollen, glandular-papillate ending of the style.

Pod oblong–ellipsoid, inflated, 15–20 × ca 8 mm, cuneate at base, short-beaked, glandular–pubescent, 1–2(–3)-seeded.

Seeds angular, sometimes ovate–globular, (6–)7(–10) × (5–)6(–8) mm, small (sometimes large), beaked, brown, black or sometimes white with an orange tinge, rarely either marbled or with black spots, surface wrinkled, sometimes smooth; chalazal tubercle prominent, as a rule heart-shaped. Hilum small, sunken, elliptic. Cotyledons pale yellow.

Seedling with hypogeal germination; roots hairy. First two leaves simple, with some small toothlets, scale-like and largely fused with two lateral scale-like 'stipulae'. Top first leaf tri-dentate (sometimes without lateral teeth). Top second leaf tri-dentate, often the central tooth elongated into a winged subulate mucro, with or without a top leaflet.

Taxonomic notes

(1) *Cicer* L. (vide Linnaeus's Sp. Pl. ed. 1: p. 738) is a monotypic genus. The basic concept of the species *Cicer arietinum* in Hort. Cliff. and in Sp. Pl. ed. 1 is the same. It is preferable to designate the specimen in the Clifford Herb. (cf. Hort. Cliff. p. 370) as the lectotype of *Cicer arietinum* L., as Verdcourt (1971) already did.

(2) Jaubert & Spach (1842) distinguished within *Cicer arietinum* three varieties: var. *vulgare*, var. *rytidospermum* and var. *macrocarpum*. Alefeld (1866) proposed six varieties: var. *vulgare* Jaub. & Sp., *macrospermum* Jaub. & Sp., *fuscum* Alef., *cruentum* Alef., all of them with blue-red flowers and with black, brown or blood-red coloured seeds; *globosum* Alef. and *album* Alef. with white flowers and orange or white coloured seeds. Jaubert & Spach as well as Alefeld distinguished the variation below the specific level by colour of the flowers and the seeds, the shape of the seeds and their seize. Popov (1928-1929) did not tackle the problem of infraspecific classification. Popova (1937) distinguished four subspecies, thirteen proles and 64 varieties, the subspecies being separated on account of dimensions, 1.000-seed weight, seed colour, and geography. The proles are distinguishable by the shape of the plant and the seed characteristics. The varieties within the proles are characterized by shape and colour of the seeds. According to her, the Ethiopian chickpeas belong to proles *abyssinicum*

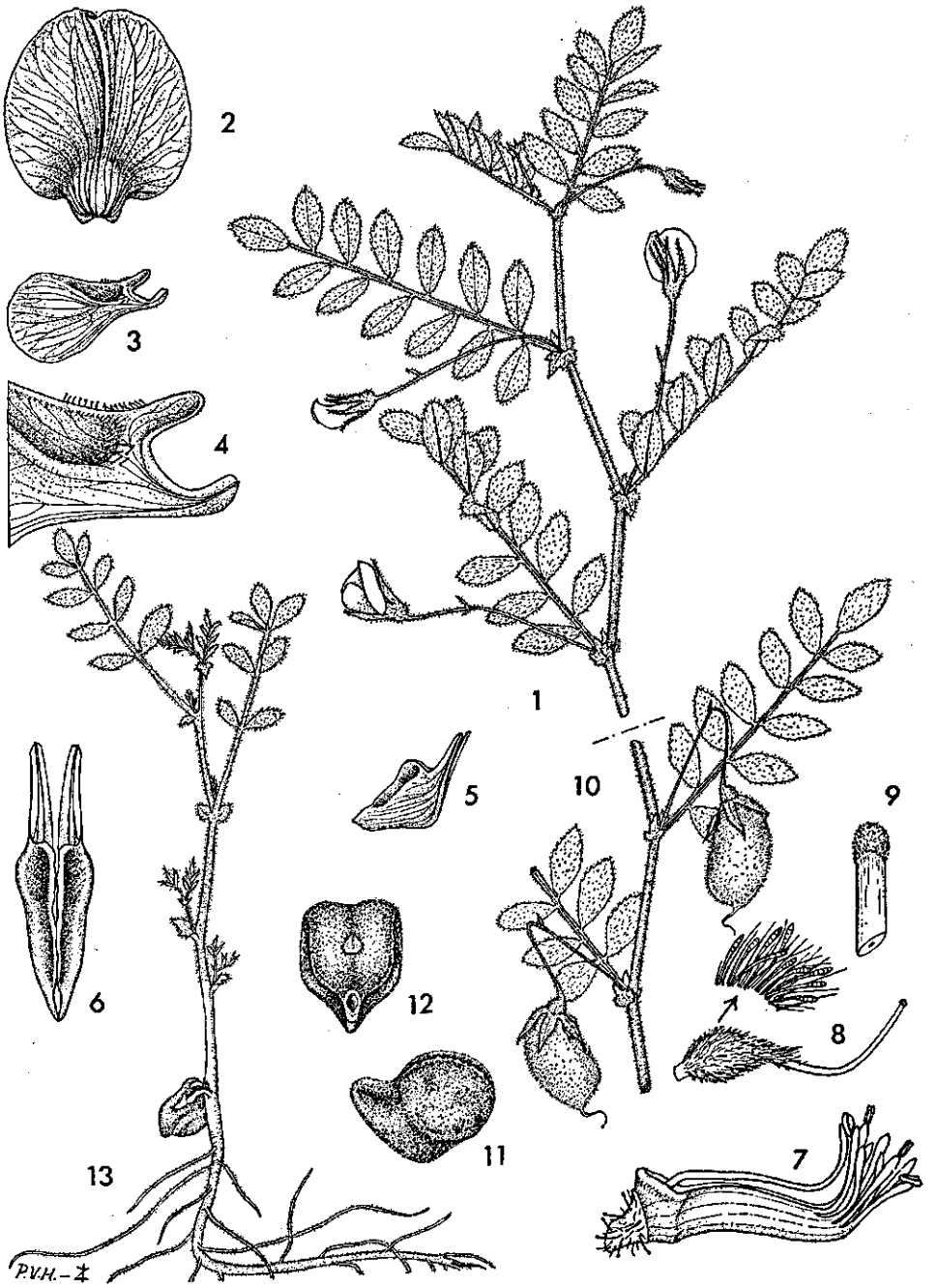

Fig. 6. *Cicer arietinum* L. cv. Abyssinico-Nigrum. – 1. branch with leaves and inflorescences (5/6×); 2. standard, adaxial view (2½×); 3. wing, adaxial view (2½×); 4. detail basis of wing (7½×); 5. keel (2½×); 6. keel, dorsal view (5×); 7. staminal sheath (5×); 8. pistil (5×) with detail hairs on ovary (ca 15×); 9. stigma (20×); 10. branch with leaves and pods (5/6×); 11. seed (2½×); 12. seed, with hilum and chalazal tubercle (2½×); 13. seedling (5/6×). – 1. WP 7697; 2–9. WP 7697 (spirit mat.); 10. WP 7698; 11–12. WP 4049B; 13. WP 7696 (spirit mat.).

of subspecies *orientale*. They are small plants, with few branches, arching at the top; seed shape angular (ram's head), sometimes globular (pea-shape) or rounded (owl's head), mainly dark coloured; flowers pinkish-red, rarely white; anthocyanin present. Within the proles *abyssinicum* Popova found eight varieties: *abyssinico-albescens, a.-roseum, a.-fulvum, a.-brunneum, a.-nigrum, a.-nigritum, a.-lutescens, a.-rubidum.* From a practical point of view this classification is difficult and therefore of limited use. Van der Maesen (1972) proposes to regard the subspecies distinguished by Popova as races, the proles as subraces. The varieties of Popova are distinguished on shape and colour of the seeds, which are found again in the different subraces. These characteristics depend only on a few genetic factors. Since an entire revision of the forms of the chickpea is not yet available, it seems advisable to use Popova's classification as modified by Van der Maesen. The Latin names used for taxa below the specific level indicate groups of cultivars.

(3) Seed types collected in Ethiopia.

(a) Seeds small, angular, surface wrinkled, black. Frequently found at market places in mixture with (f). This type corresponds with var. *abyssinico-nigrum* G. Pop. Sometimes larger seeds are found (var. *abyssinico-nigritum* G. Pop.), but it is not useful here to separate these as a different type. I designate this taxon as cv. Abyssinico-Nigrum (based on WP 5487A, WP 7717, WP 7718 and WP 7719).

(b) Seeds small, globular, surface smooth–wrinkled, white with an orange tinge. Sometimes found as admixture. This type corresponds with var. *abyssinico-lutescens* G. Pop. I designate this taxon as cv. Abyssinico-Lutescens (based on WP 3270, WP 7688, WP 7689 and WP 7690).

(c) Seeds large, angular, surface wrinkled, white with an orange tinge. Collected at Debre Zeit by the Experimental Station. Italian origin is not impossible. This type has not been found at the markets; Popova does not mention it. I designate this taxon as cv. Italian Wonder (based on WP 4886, WP 7699, WP 7700 and WP 7701).

(d) Seeds large, angular, surface wrinkled, light brown. Sometimes found as admixture, and also in selections of the Debre Zeit Experimental Station from local material. This type has not been mentioned by Popova; it seems to be close to var. *a.-brunneum* G. Pop. I designate this taxon as cv. Lion of Juda (based on WP 2985, WP 7682, WP 7683 and WP 7684).

(e) Seeds large, globular, surface slightly wrinkled, red-brown. Selections at the Debre Zeit Experimental Station from local material. It has never been encountered by the author at market places. It corresponds with var. *a.-rubidum* G. Pop. I designate this taxon as cv. Abyssinico-Rubidum (based on WP 4895, WP 7702, WP 7703 and WP 7704).

(f) Seeds small, angular, surface wrinkled, brown. Frequently found at market places, also mixed with (a). It corresponds with var. *a.-brunneum* G. Pop. I designate this taxon as cv. Abyssinico-Brunneum (based on WP 3300, WP 7693, WP 7694 and WP 7695).

(g) Rarely seeds are found which are marbled or have black spots. I designate this taxon as cv. Menelik (based on WP 5000D).

(4) Plants raised from seed types (b) and (c) give white flowers, whereas plants

grown from seeds of (a), (d), (e) and (f) produce red-purple flowers. As a rule the F_1-seeds are equal to the original ones in shape and colour.

(5) The description is based on the following specimens.

Tigre	Axum market: Sl 935; Adi Shoa market: Sl 1027.
Begemdir	Gondar market: WP 5000A–WP 5000D, WP 5001A–WP 5001D, Sl 913, Sl 915; Infranz market: Sl 854.
Gojam	Bahar Dar market: WP 4965A; Elias market: Sl 793.
Wollo	Bati market: WP 4016A–WP4016C, Sl 1044, Sl 1045; Kombolcha market: Sl 971, Sl 972; Dese market: Sl 1101; Robi market: Sl 1155.
Shoa	Debre Zeit market WP 2984A, WP 2984B, WP 2985; Collection Debre Zeit Exp. Station: WP 4886–WP 4897, WP 4898A, WP 4898B, WP 4899.
Illubabor	Bedelle market: WP 5487A, WP 5487B.
Kefa	Assendabo market: WP 3370; Jima market: WP 3299A–WP 3299D, WP 3300, Sl 127, Sl 133, Sl 134, Sl 136; Agaro market: WP 3270, Sl 87, Sl 93, Sl 110.
Gamu Gofa	Gidole market: WP 3232A, WP 3232B, WP 3234A–WP 3234C.
Sidamo	Soddo market: WP 4049A–WP 4049C; Yirga Alem market: WP 2654A, WP 2654B; Negelli market: WP 2793A–WP 2793D; just east of Negelli, in field: J. J. de Wilde 6008.
Bale	Adaba market: J. J. de Wilde 7370C; Goba market: Sl 1227; Habbe market: J. J. de Wilde 7368A.
Arussi	Sire market: Sl 141A.
Hararge	Asbe Teferi market: Sl 466; Waichu market: Sl 510; Dire Dawa market: WP 117A, WP 117B, WP 140; Alemaya market: WP 8A, WP 8B; Harar market: WP 40A, WP 40B, WP 47A, WP 47B, WP 53A, WP 53B, WP 54, WP 97A, WP 97B; garden Alemaya: WP 214, WP 215, WP 249, WP 250, WP 260, WP 261, WP 268–WP 270, WP 346, WP 347, WP 367, WP 726, WP 735, WP 739, WP 1187, WP 1778, WP 1799, WP 1829, WP 1830, WP 2179; K'uni market: Sl 756; Feddis market: Sl 168; Jijiga market: Sl 347.
Grown at Wageningen	WP 5600–WP 5603, WP 5728–WP 5735, WP 5769–WP 5774, WP 5794–WP 5803, WP 6032–WP 6037, WP 6102, WP 6209–WP 6211, WP 6499–WP 6503, WP 6609–WP 6616, WP 6832–WP 6840, WP 7667–WP 7722. (WP 7667–WP 7722 have been raised in the greenhouse).

Ecology

Chickpea, being an annual, needs high solar radiation and is a quantitative long-day plant. It needs only moderately high temperatures. A daily temperature fluctuation is preferred, but the temperature amplitude should not be too wide. It must have cold or cool nights with dew for successful cultivation. High relative air humidity is not harmful, but the soil should definitely not be too wet. It cannot tolerate heavy rains and thus is unsuited to the wet tropics where it often fails to flower. It grows best on heavy clay soils and in a rough seedbed. It is moderately resistant to drought. Such a combination of ecological factors is usually found at high altitudes both north and south of the equator and should therefore be considered the ecological optimum (Van der Maesen, 1972).

The present cultivars are adapted to soils of only moderate fertility. The Russian cultivars, for instance, are relatively insensitive to the photoperiod; they are adapted to high latitudes, and less sensitive to large fluctuations in daylength. Ethiopian cultivars are more sensitive to the photoperiod (Van der Maesen, 1972).

Husbandry

In India chickpea is usually grown as a cold weather crop, either mixed with cereals and other crops or in pure stand. Sometimes it is irrigated (India, Iran, Egypt). It is harvested 4–6 months after sowing and cut, dried and threshed. Yields range between 450–2200 kg/ha dried pulse, with an average of 675 kg/ha (Purseglove, 1968).

In northern and central Ethiopia, and in the Chercher Highlands chickpeas are mostly sown after the main rainy season, at the end of September. The sowing period may last till January. Harvest takes place in or around February. In the Yerer-Kereyu Highlands, east of Addis Abeba, a second chickpea crop is sown on the same field after the onset of the small rains at the end of April (Kuls, 1957). The crop grows well even on poor soils, but it is generally cultivated on heavy clay soils. It is an important legume crop in several rotations on heavy black soils in Shoa and Begemdir, following t'ef or wheat, or preceding wheat as is the case on red clay soils in the Yerer-Kereyu Highlands. In the ensat areas in south-west Ethiopia chickpea is used in rotation with wheat. Moreover, chickpea is frequently used as a second crop. Generally it is grown in monoculture, but it is found in an admixture to, for instance, safflower or sorghum (Simoons, 1960). Average yields amount to about 620 kg/ha.

Uses

Seeds, young shoots and pods are used for human consumption, the rest of the plant, after threshing, for fodder. In India whole dried seeds are eaten either cooked or boiled or as dhal, prepared by splitting the seeds in a mill and removing the husk. Flour, made from ground seeds, is one of the chief ingredients with ghee and sugar for many forms of Indian confectionery. Green pods and tender shoots are used as a vegetable. An acrid exudation from the glandular hairs is collected by spreading a cloth over the crop at night, absorbing it with the dew. It contains malic and oxalic acid and is used medicinally and as vinegar (Purseglove, 1968).

In Ethiopia seeds are consumed raw (when young), roasted or in 'wot". Sometimes an unleavened bread is made from chickpea-flour. In the t'ej houses, the roasted, salted 'shimbra' are served as snacks. The dried vines are used as cattle feed.

Protein content

Leaves: 4–8% (Terra, 1966); ripe seeds: 20.1% (Darby et al., 1959), ca 20% (Terra, 1966).

The first limiting amino acid is tryptophan, followed by methionine and cystine (Aykroyd & Doughty, 1964).

(5) Dolichos lablab L.

Figs 7, 8; Plates 9–11

'*Dolichos*': Gr. dolichos = long. The adjective used by the ancient Greek as a plant name (a noun) meant a high winding plant with long (slender) pods, nevertheless certainly a different taxon from present-day *Dolichos*.
'*lablab*': a Hindustani plant name, originally of uncertain meaning.

Linnaeus, Sp. Pl. ed. 1: p. 725 (1753).
Type: Habitat in Egypt; '*Dolichos* leguminibus ovato-acinaciformibus, seminibus ovatis hilo arcuato versus alteram extremitatem' (UPS, Burser Herbarium no. XIX-55, lecto.!).

Synonyms

Dolichos bengalensis Jacq., Hort. Vindob. 2: p. 57 (1772).
Lablab niger Med., Vorles. Churpf. Ges. 2: p. 354 (1787).
Lablab vulgaris Savi, Nuovo G. Lett. Pisa 8: p. 116, fig. 8, a-c (1824).
?*Lablab purpureus* (L.) Sweet, Hort. Brit. ed. 1: p. 481 (1827).
Lablavia vulgaris Don, in: Sweet, Brit. Fl. Gard. Ser. 2: t. 236 (1834).
Dolichos lablab L. ssp. *lablab* (L.) Rivals, Revue Bot. appl. Agric. trop. 33: p. 521 (1953).
Dolichos lablab ssp. *ensiformis* (Thunb.) Rivals, l.c.
Dolichos lablab ssp. *bengalensis* (Jacq.) Rivals, l.c. p. 522.
Lablab niger ssp. *bengalensis* (Jacq.) Cuf., Bull. Jard. bot. État Brux. 25(3): p. 340 (1955).
Lablab purpureus ssp. *uncinatus* Verdc., Kew Bull. 24(3): p. 410-411 (1970).
Lablab purpureus ssp. *purpureus* (L.) Verdc., l.c. p. 410.
Lablab purpureus ssp. *bengalensis* (Jacq.) Verdc., l.c. p. 411.
For more synonyms: see Cufodontis, Bull. Jard. bot. État Brux. 25(3): p. 339-340 (1955) and 39(4), suppl. XXV (1969), and Verdcourt, Kew Bull. 24(3): p. 410-411 (1970).

Literature

1763: Adanson, Familles des plantes 2: p. 325, 550. (tax.)
1827: Sweet, Hortus Brittanicus. ed. 1: p. 481. (tax.)
1832: Roxburgh, Flora Indica 3, ed. Carey: p. 305-306. (tax.)
1911: Backer, Schoolflora voor Java: p. 376-377. (tax.)
1915: Piper & Morse, U.S.D.A. Bull. no 318. (tax. + agric.)
1937: Ivanov, in: Vavilov & Wulff, eds, Koultournaja Flora SSSR 4: p. 649-659. (tax.)
1953: Rivals, Revue Bot. appl. Agr. trop. 33: p. 314-322, 518-537. See also: J. Agric. trop. Bot. appl. 7 (1960): p. 447-450. (tax. + agric.)
1953: Whyte et al., Legumes in agriculture: p. 272-273. (agric.)
1955: Cufodontis, Enumeratio, Bull. Jard. bot. État Brux. 25(3): p. 339-340. See also: 39(4), suppl. XXV (1969). (tax.)
1958: Kuls, Frankf. Geogr. Hft 32: p. 109. (agric.)
1960: Simoons, Northwest Ethiopia: p. 110. (agric.)
1962: Tardieu, Agron. trop. 17(1): p. 33-66. (agric.)
1963: Schaaffhausen, v., Econ. Bot. 17(2): p. 146-153. (agric.)
1965: Busson, Plantes alimentaires de l'ouest africain: p. 239-240. (agric.)
1965: Verdcourt, Regnum veg. 40: p. 26-27. (tax.)
1966: Burkill, Dict. ec. prod. Malay Peninsula 1: p. 864-867. (agric.)
1966: Stanton et al., Grain legumes in Africa: p. 95-99. (agric.)
1966: Terra, Tropical vegetables: p. 44-45. (agric.)
1968: Purseglove, Tropical Crops, Dicotyl. 1: p. 273-276. (tax. + agric.)
1968: Verdcourt, Taxon 17(2): p. 172-173. See also p. 327-328. (tax.)

Leaves alternate, 3-foliolate. Petiole (3.0–)6.0–17.0(–29.5) cm long, slender, grooved above, with swollen dark green pulvinus. Rachis (0.5–)1.5–4.5(–6.5) cm long, grooved above, topped by a leaflet.

Leaflets: First two leaflets opposite and asymmetrical, top leaflet symmetrical and sometimes slightly longer, with petiolule short and sometimes slightly grooved above with indumentum denser than on petiole, (sometimes very) broadly ovate, (4.0–)7.0–13.0(–20.5) × (3.5–)5.0–14.5(–19.0) cm, entire, truncate at base, cuspidate at top, palmately 3-nerved and green and glabrescent above, with veins and edge of leaflets thinly, silvery pubescent (yellow-brown hairlets also present), grey-green below with venation similar to upper surface but more prominent.

Stipellae small, stoutly subulate, slightly pubescent, sometimes with lighter coloured venation, at the base of the petiolule, 1 per lateral leaflet, 2 per top leaflet.

Inflorescence a stiff, axillary raceme with many flowers. Peduncle (4.0–)8.5–13.5 (–23.0) cm long, often somewhat compressed, glabrescent, as is the rachis, (2.5–)6.0–13.0(–24.5) cm long; flowers arising 1–5 together from tubercles on rachis; bracts 1 per flower, deciduous, ovate to elliptic, ca 5 mm long, with prominent veins, sparsely pubescent; pedicels short, square, sparsely pubescent, with two bracteoles attached at base of the calyx. Bracteoles obovate, ca 5 mm long, sparsely pubescent.

Calyx campanulate, pubescent; tube gibbous dorsally, ca 4 mm long, somewhat fleshy at base becoming shallowly saucer-shaped when older and subtending the thin upper calyx-lobes; lobes 5, the upper pair of lobes connate, forming an entire or emarginate lip, the other three lobes subequal, triangular, ca 2–3 mm long, acute at top.

Corolla: Standard erect, usually reflexed, transversely elliptic, ca 13(–15) × (17–)20(–22) mm, clawed, bi-auriculate, with left and right two prominent and (below these) two smaller callosities right above the auricles (the large callosities are hinges to the abaxial 'pockets' of the wings), obcordate at top, glabrous, white, purple or white with purple tinge. Wings obovate, 16–19 × ca 11 mm, clawed, auriculate, bi-'pocketed', rounded at top, glabrous, white or purple, adherent to the standard and the keel. Keel hook-shaped, ca 15 × ca 4 mm, clawed, split dorsally from the base, with edges glandular-ciliolate (hairlets blunt, club-shaped) until becoming short connate, and some distance below the top then glabrous and further towards the tip again free and overlapping, ventrally split near the base, on the horizontal part left and right a prominent 'pocket', and also a small 'pocket' at the top (vertical part), glabrous, white or white with a purple-tinged top.

Androecium: Stamens diadelphous (9 + 1). Vexillary stamen free, ca 15(–17) mm long, flattening and geniculate near the base, tapering towards the top, the upper third abruptly upturned. Staminal sheath ca 12(–14) mm long, free part of filaments alternately longer and shorter, when longer ca 6(–8) mm long, when shorter ca 4.5 mm long, slightly winged, with apical part abruptly upturned. Anthers ellipsoid, ca 1 mm long, basifixed, irregularly minutely denticulate, yellow.

Disk annular, slightly ribbed.

Gynoecium: Ovary sessile, ca 10 mm long, finely pubescent, long-beaked, ca 4-

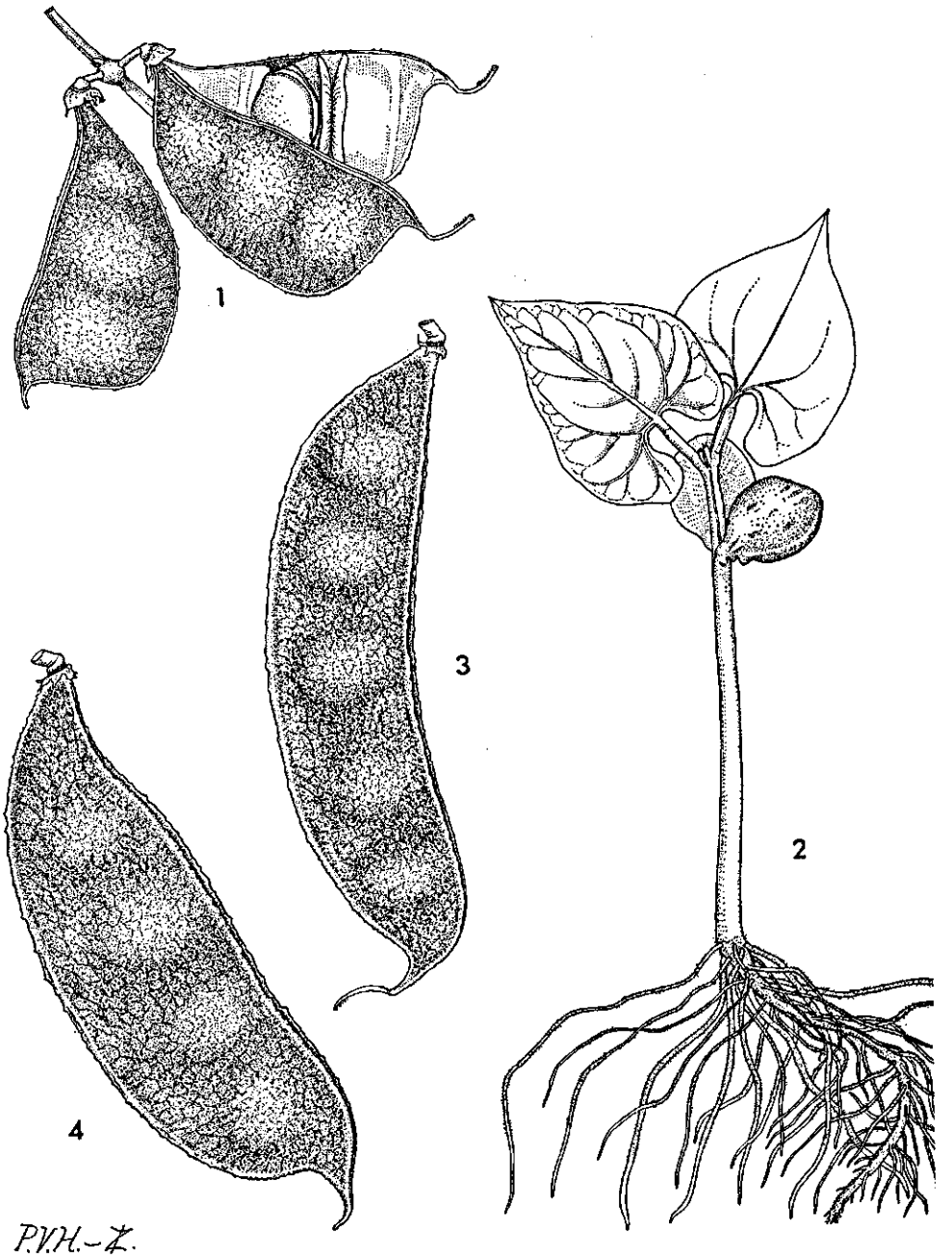

Fig. 8. *Dolichos lablab* L. cv. Shankalla Wonder. – 1. pods ($^5/_6\times$); 2. seedling ($^5/_6\times$). Cv. Black Alamata. – 3. pod ($^5/_6\times$); 4. immature pod ($^5/_6\times$). – 1. WP 8624 (spirit mat.); 2. WP 7558 (spirit mat.); 3. WP 8635 (spirit mat.); 4. WP 488 (spirit mat.).

ovulate, with inner ovarial wall speckled with tiny brown dots. Style abruptly upturned, ca 8 mm long, laterally compressed, with basal part glabrous and apical part thinly pubescent, adaxially with long hairs, persistent on pod. Stigma capitate, glandular.

Pod crescent-shaped to more or less straight and oblong, or also dorsally straight and ventrally deeply curving while suddenly near the top returning towards the slender beak, laterally compressed, bulging over the seeds, (4.0–)5.0–6.0(–10.0) × (1.0–)1.5–2.0(–3.0) cm, beaked, style persistent, tuberculate along both margins, sometimes grooved dorsally, pubescent or glabrescent, sometimes purplish, (2–)4(–6)-seeded. The large-celled exocarp of the ripe pod showing numerous tiny cracks and becoming more or less detached from the mesocarp.

Seeds ovoid, as a rule laterally compressed, sometimes more rounded, 9–12(–13.5) × 6.5–9(–11) mm, black, red-brown, white, black with red-brown spots, brown with dark brown or black spots, as well as white with partly brown. Hilum oblong, ca 10 mm long, covered with aril. Aril prominent, white, extending for more than one-third along the circumference of the seed. Cotyledons pale yellow.

Seedling with epigeal germination. Taproot with many laterals and several well-developed adventitious roots. Cotyledons thick, elliptic, sometimes obovate, lower surface often slightly grooved. Hypocotyl green, sometimes purplish. First two leaves opposite, simple, cordate, (2.5–)4.0–5.0(–6.0) × (2.5–)3.0–4.0(–4.5) cm, acuminate at top. Stipulae of the two leaves partly connate. Stipellae as a rule absent, in very few cases one or two stipellae present.

Note

Plants raised in the greenhouse at Wageningen under long-day circumstances produced luxurious vegetative growth, but did not flower and fruit. Under short-day (11 hours) all plants flowered and produced fruits (WP 8587–WP 8588, WP 8597–WP8598, WP 8600–WP 8601, WP 8603–WP 8612, WP 8623–WP 8624, WP 8628–WP 8629, WP 8634–WP 8635).

Taxonomic notes

(1) In Sp. Pl. ed. 1 Linnaeus took over the basic concept of *Dolichos lablab* as adopted by Van Royen. In the Van Royen Herbarium at Leiden three specimens are present carrying the name *Dolichos lablab* L. of which two are not *Dolichos lablab* as Van Royen (and Linnaeus) originally intended. The third specimen consists of a branch with inflorescence (with flowers and very young fruits) and a label is present saying '*Phaseolus*. Huic flos albus'. It is definitely *Dolichos lablab* but on the label no reference is found to Van Royen's Florae Leydensis Prodromus p. 368 (1740), where this *Dolichos* species has been described as follows: '*Dolichos* leguminibus ovato-acinaciformibus, seminibus ovatis hilo versus alteram extremitatem arcuato cinctis'. Moreover, the specimen carries no mature fruits. Consequently, it is not suitable to be selected as the lectotype and it may be assumed that the original specimen(s) in the Van Royen Herbarium which Linnaeus saw, are no longer extant.

The second reference in Sp. Pl. ed. 1 is to Hort. Ups. However, in Uppsala no Linnaean specimen of *Dolichos lablab* is present.

Linnaeus further refers to '*Phaseolus* niger Lablab' of Alpinus. In his De Plantis Aegypti liber p. 74 (1592), Alpinus gives a description of this taxon together with a plate (l.c. p. 75). He refers to this taxon as follows: 'Est arbor sarmentosa, quae crescit ad vitis magnitudinem'. The plate shows a tree with pendent fruits. However, this plate does not show any resemblance with *Dolichos lablab* and is not recognizable as such. Linnaeus referred to this plate, but it is not suitable for selection as the lectotype.

Finally Linnaeus referred in Sp. Pl. ed. 1 to '*Phaseolus* aegyptius, nigro semine' of Bauhin. In his Pinax theatri botanici p. 341 (1623) Bauhin listed under '*Phaseolus* Aegyptiacus sive Lablab' the taxon '*Phaseolus* Aegyptiacus nigro semine' and quoted as synonyms 'Phaseoli genus Leplap sive Lablab' of Clusius (Rariorum ... stirpium ... Pannoniam ... (1583)), '*Phaseolus* peregrinus Leblab' of Clusius (Rariorum plantarum historiae (1601)), and '*Phaseolus* niger Lablab vocatus' of Alpinus (1592). In the Pinax herbarium of Bauhin at Basle a specimen is present with flowers and fruits carrying a label saying: '*Phaseolus* Leplap ? dectus. Zuing e Deldius' (final words illegible). This specimen is accompanied by a plate from Clusius's Rariorum ... stirpium ... Pannoniam ... of 1583, p. 731, showing a fruit and a seed of 'Leplap sive Leblab'. This plate of Clusius, in fact, shows *Dolichos lablab* L. The white arillus characteristic for *D. lablab* is clearly visible. However, the specimen in Bauhin's herbarium is not *Dolichos lablab*, but *Phaseolus lunatus* L. cv.-group Lunatus. Even if a specimen of *D. lablab* was at one time present in Bauhin's herbarium, it did not belong to the original material consulted by Linnaeus and, consequently, could not be considered a suitable choice as the lectotype of *D. lablab* (see Code, 1972, Art. 7: p. 7 and p. 75 under 4a).

In the Burser herbarium at Uppsala a specimen of *Dolichos lablab* is present (XIX.55). It carries the inscription: '*Phaseolus* Aegyptiacus nigro semine Bauh. Leplap Clus. pann. Basileae in horti Bauhini'. This specimen agrees with the protologue in Sp. Pl. ed. 1, except for the shape of the pod which is more oblong than acinaciform. Although it is most likely that Linnaeus has seen this specimen, it appears not from the protologue. In the preface of the first edition of Sp. Pl. Linnaeus stated that he consulted the Burser Herbarium; this statement justifies the conclusion that the specimen of *D. lablab* in the Burser herbarium belongs to the original material on which Linnaeus based his *Dolichos lablab*. Consequently this specimen, which is in agreement with the protologue in Sp. Pl. ed. 1, is suitable for selection as the lectotype of *Dolichos lablab* L.

Savage (1936) referred to a Linnaean manuscript containing Linnaeus's determinations of the majority of the plants in the Burser Herbarium. It is clear, according to Savage, that it is a compilation previous in date to the first edition of Sp. Pl., but containing subsequent additions. From this Linnaean manuscript it appears that the specimen in Burser's herbarium nr. XIX-55 has been identified by Linnaeus as *Dolichos lablab*. This entry is printed in Savage's Caroli Linnaei Determinationes in Hortum siccum Joachimi Burseri (Cat. MSS Libr. Linn. Soc. II, 1937). This gives additional support for the choice of this specimen as the lectotype of *Dolichos lablab*.

In his own copy of Bauhin's Pinax Linnaeus wrote '*Phaseolus lablab*' in the margin of '*Phaseolus* Aegyptiacus nigro semine' (Pinax, p. 341). In a manuscript of Sp. Pl.,

Linnaeus did start to write '*Phaseolus lablab*' after the seventh species of the genus *Phaseolus*, but crossed it. So 'lablab' appeared as the first species of *Dolichos* as it does in Sp. Pl. ed. 1 (O'Grady, personal communication by letter 7 August 1973).

(2) In Flora Indica, Roxburgh (1832) distinguishes within *Dolichos lablab* seven varieties of which five are cultivated and two are wild. Within the cultivated varieties the first coincides with the second group of cultivars mentioned above. Backer (1911) named it *Dolichos lablab* α *typica*. The other cultivated varieties mentioned by Roxburgh fit into the first group of cultivars mentioned above. Backer named it *D. lablab* β *lignosa*.

Burkill (1966) refers to both groups as var. *typica* Backer and var. *lignosa* Backer. Backer for Java (Indonesia) found the division made by Roxburgh correct and indicated that Prain (1897?) in his Materials for a Flora of the Malaya Peninsula confused both groups. This mixing up is found back in the names Purseglove (1968) uses.

Ivanov (1937) distinguishes within *D. lablab* two subspecies based solely on seed dimensions: ssp. *lignosus* (L.) Ivan. and ssp. *vulgaris* (Savi) Ivan. The subdivision of ssp. *vulgaris* is then based on the colour of the flowers which is, according to Rivals (1953), less important than the characteristics of the pods and the seeds. Rivals adopted the division already used by Thompstone and Sawyer (1914) for Burman hyacinth beans, which is the following:

(a) ssp. *lablab:* mature seeds with the long axis at right angles to the suture; pods dehiscent or indehiscent; seeds not longer than $\frac{1}{2}$–$\frac{3}{4}$ of the width of the mature pod;
(b) ssp. *ensiformis* (Thunb.) Rivals: mature seeds with the long axis more or less obliquely to the suture, nearly filling the mature pod; pods indehiscent, when young difficult to distinguish from ssp. *lablab* (intermediate between *lablab* and *bengalensis*);
(c) ssp. *bengalensis* (Jacq.) Rivals: mature seeds with long axis parallel to the suture, more or less filling the mature pod, gibbous dorsally and at base; pods indehiscent.

Verdcourt (1970, '71) classifies the infraspecific variants of *Lablab purpureus* (L.) Sweet (illegit. synonym for *D. lablab*) as follows:

(a) ssp. *uncinatus* Verdc.[10]: wild plants with pods ± 4 cm long, 1.5 cm wide. Ssp. *uncinatus* is cultivated in tropical East Africa but it is always obviously of purely local origin;
(b) ssp. *purpureus:* cultivated plants with larger pods than (a), similar in shape to the wild forms, ± emarginate below the persistent style, up to 10 cm long, 4 cm wide;
(c) ssp. *bengalensis* (Jacq.) Verdc.: cultivated plants with longer pods than (a), very

10. In introducing *Lablab purpureus* (L.) Sweet ssp. *uncinatus* Verdc., subsp. nov., Verdcourt (1970) refers to *Lablab uncinatus* A. Rich. in Tent. Fl. Abyss. 1: p. 225 (1847), and added in 1971: 'nom. nud., based on Ethiopia, Modat, Schimper 1779'. Richard added to his *Lablab vulgaris* Savi the following note: 'cette plante varie beaucoup dans la forme de ses gousses, qui sont plus au moins bossues vers leur sommet. Nous pensons que les échantillons distribués par MM Hochstetter et Steudel sous le nom de *Lablab uncinatus* A. Braun, in litt., il est probablement qu'une des formes variées du *Lablab vulgaris*'.

similar to kidney beans, narrowly oblong or linear–oblong, up to 14 cm long, 1–2.5 cm wide.

According to Rivals's division the infraspecific variation of *Dolichos lablab* can be designated as follows: cv.-group Lablab, cv.-group Ensiformis and cv.-group Bengalensis. The Ethiopian group fits into cv.-group Lablab. Possibly one of the samples belongs to cv.-group Ensiformis, but a definite decision is not possible.

Within cv.-group Lablab the following Ethiopian types can be distinguished.
(a) Seeds ± black (sometimes red-brown spots present); I designate this taxon as cv. Burnt Face (based on WP 3208, WP 7535 and WP 7536).
(b) Seeds red (sometimes with slightly darker spots); I designate this taxon as cv. Red Konso (based on WP 3224C, WP 7539, WP 8597 and WP 8598).
(c) Seeds white; I designate this taxon as cv. White Lady (based on WP 3226C, WP 7549, WP 8607 and WP 8608).
(d) Seeds white with large brown spots; I designate this taxon as cv. Brown Sagan (based on WP 3226H, WP 7556, WP 8611 and WP 8612).
(e) Seeds brown with black spots; I designate this taxon as cv. Speckled Teferi (based on WP 2566C).
(f) Seeds large, brown; I designate this taxon as cv. Shankalla Wonder (based on WP 3384, WP 7558, WP 8623 and WP 8624).
(g) Seeds large, black with brown varying spots; possibly belonging to cv.-group Ensiformis, but a definite conclusion is not possible, since the specimen only has young fruits; I designate this taxon as cv. Black Alamata (based on WP 4025A, WP 8634 and WP 8635).

(3) The name *Dolichos* first appeared in the work of Theophrastus (372-287 B.C.) and was described as a genus by Linnaeus in the first edition of Genera Plantarum (1737) and maintained in the 5th ed. (1754). He included 12 species in Sp. Pl. ed. 1 (1753). Looking through older literature it is evident, according to Verdcourt (1965), that *Dolichos lablab* L. can be looked upon as the historical type of the genus and this choice has been positively made on two occasions at least (Britton & Wilson, 1924; Hitchcock & Green, 1929). *Dolichos biflorus* L. has been more recently either proposed as the type (Camp, Rickett & Weatherby, 1947) or accepted as such (Philips, 1951).

Most recent workers on *Leguminosae* have considered that *D. lablab* belongs to a small genus, *Lablab* Adans., distinct from *Dolichos* L., in the sense of these workers, but not of Linnaeus.

Adanson (1763) distinguishes the genera *Lablab* and *Dolichos*. *Lablab* is, according to him, synonymous with *Dolichos* L., and based on Alpinus. *Dolichos* is based on Theophrastus. In the Index (p. 550) Adanson gives for *Dolichos* Téofr. the following information: 'Niébé. Seneg.; Alubias. Luzit.' Niébé is a well-known Senegalese name for *Vigna unguiculata* (L.) Walp. Since *Dolichos* L. (1753) is, according to Adanson, synonymous with *Lablab* Adans. (1763), the name *Dolichos* has priority over *Lablab* and there is no ground for maintaining *Lablab* in the sense of Adanson.

The acceptance of *D. lablab* as the type of *Dolichos* L. would restrict the genus to

this species and any few allies that it may be considered to have. This typification of *Dolichos* would lead, according to Verdcourt (1965), to highly undesirable nomenclatural consequences. The search for finding a more suitable type, however, has been without result, since none of the other species included in *Dolichos* by Linnaeus in 1753 is suitable for selection as the type of the generic name (Verdcourt, 1965). Consequently, *D. lablab* L. should be maintained as the type of *Dolichos* L. since it had, by virtue of being a well-known cultivated plant, become one of the best known species of *Dolichos* and, moreover, had been formally chosen as lectotype on several occasions (quoted by Verdcourt, 1968; see also Taxon 17(2), 1968: p. 327-328).

Later on, Verdcourt (1968) proposed *Dolichos trilobus* L. pro parte, a species included in Sp. Pl. ed. 1, as the new type of the genus *Dolichos*.

From the point of view of nomenclatural stability Verdcourt (1970) is of the opinion that there is much to be said for keeping a large genus *Dolichos* (including *Lablab*), but scientifically the resulting conglomeration would be of little value. It is difficult to reconcile the great variety of stylar structures and pollen-grain sculpture in one genus. As soon as splitting is considered, difficulties arise with small satellite groups as to whether they should be treated as genera or subgenera. More important is the fact that the entities should be recognized at some level. As Verdcourt (1970) rightly puts it: 'in awkward cases one is tempted to avoid numerous changes by lumping or splitting more than would have been the case if there were no nomenclatural difficulties'.

In 1972 (Taxon 21(4)) the Committee for Spermatophyta finally accepted the proposal of Verdcourt for the retypification of *Dolichos* L. by *D. trilobus* L. The Committee recommends conservation of the name *Dolichos* in this way, over the objections of a strongly dissenting minority. The main principal reason for dissent is as follows: objection to the abandonment of the historic type of *Dolichos*, *D. lablab* L., 'an established typification that has nothing wrong with it except that people have chosen to ignore it and do things contrary to correct practice. This merely encourages them to disregard the Code with the assurance that the problems they create will be solved by invoking conservation'.

The abandonment of a type because it is a-typical, as is the principal reason for rejecting *Dolichos lablab* by Verdcourt, is reprehensible. Article 7, note 1 of the Code says that 'the nomenclatural type is not necessarily the most typical or representative element of a taxon; it is that element with which the name is permanently associated'. Secondly, modern monographic studies of *Dolichos* which cover and integrate all relevant aspects of this genus, including pollen morphology and biochemical information, are not available. This may urge caution and reserve in suggesting a split of the genus *Dolichos*. Thirdly, name changes which are not based on well-balanced arguments, may result in the future in new name changes. In this respect I totally agree with Verdcourt (1965) that 'to a field worker already exceedingly tired of the constant name changing necessitated by taxonomic research, it will undoubtedly commend itself'. Fourthly, some question aroused as to the typification of *D. trilobus* by the Plukenet reference (Pluk., Alm. p. 292, t. 214, f. 3), since a specimen is present in LINN (900.12) with the reference by number to Sp. Pl. ed. 1. According to article

9, note 1 of the Code, a specimen has preference over a drawing or description. Leaving this question for the moment for what it is, one wonders what happened between 1968 and 1971 to see *D. trilobus* being typified in the Flora of Trop. East Africa (l.c. p. 678) by 'several specimens in Herb. Plukenet (BM, syn.!)', and not by the Plukenet reference. This is not a proper typification and, above all, Linnaeus in Sp. Pl. ed. 1 did not refer to (a) specimen(s) in Plukenet's Herb., but to a plate in his Almagestum botanicum.

(4) Instead of *Dolichos lablab* L. Verdcourt uses the combination *Lablab purpureus* (L.) Sweet. The arguments for using this combination are not convincing. Verdcourt (1968), who places *Dolichos lablab* in the genus *Lablab* Adans., pointed out that Sweet (1827) used an older epithet being 'purpureus' from *D. purpureus* L. (1763) than Medikus with *Lablab niger* (1787), which then has priority. Verdcourt (1971) communicates that the type of *Lablab purpureus* has not been found, since the specimen *D.* ? *purpureus* in LINN does not agree with the description. Since he omitted to prove that *D. lablab* and *D. purpureus* are names for the same plant, and moreover, since Verdcourt did not designate a neotype which typifies the used combination *Lablab purpureus*, this binomial must be rejected. Therefore the oldest combination made in the genus *Lablab* is *L. niger* Medikus.

(5) The following differences were found between plants raised at Wageningen and in Ethiopia.

	Petiole (cm)	Rachis (cm)	Leaflet		Inflorescence	
			length (cm)	width (cm)	peduncle (cm)	rachis (cm)
Wageningen	3.0–29.5	1.5–6.5	6.0–20.5	4.0–19.0	4.0–23.0	2.5–13.0
Ethiopia	4.5–18.0	0.5–5.0	4.0–14.5	3.5–13.0	5.5–17.5	4.0–24.5

(6) The description is based on the following specimens.

Eritrea	10 km south of Nefasit, in field: J. J. de Wilde 4510.
Wollo	Alamata, in garden: WP 4025A, WP 4025B; Dese market: Sl 1106A.
Wellega	55 km past Nekemte on Gimbi road, in Shankalla village: WP 3384.
Kefa	Gobe (north–west of Maji), in fence: J. J. de Wilde 6181; Jima area: F. G. Meyer 7892 (K!), Siegenthaler 1481 (K!).
Gamu Gofa	1.5 km past Gidole on Arba Minch road, in garden: WP 3207, WP 3208; 54 km past Gidole on Giarso track, in field: WP 3212A, WP 3212B, WP 3213; 58 km past Gidole on Giarso track, in field: WP 3216, WP 3217; Giarso market: WP 3224A–WP 3224D, WP 3225A–WP 3225F, WP 3226C–WP 3226H.
Sidamo	6 km past Dila on Wenago road, in garden: WP 2825.
Hararge	Asbe Teferi, in fence: WP 2566A–WP 2566C; 8 km past Dire Dawa on Harar road, in fence: WP 2215, WP 3015A, WP 3015B; Alemaya, in fence: WP 2550, WP 3396A; College of Agriculture: WP 488; around Harar, in garden: WP 3513.
Grown at Wageningen	WP 7007, WP 7008, WP 7531–WP 7563, WP 7565, WP 8587, WP 8588, WP 8597–WP 8601, WP 8603–WP 8612, WP 8623, WP 8624, WP 8628, WP 8629, WP 8634, WP 8635.

The numbers WP 3119 and WP 3120 collected at Kulumsa farm north of Asella are not included, since their provenance is not clear. Seeds were obtained from Bako Experimental Station under the name Dahilar lablab.

Ecology

Lablab has a similar adaptation to the climate as the cowpea (Whyte et al., 1953). It is hardy and can be grown in areas with a low rainfall of 600–900 mm. Night frost will damage the leaves but, if light, it will not kill the plant. It can tolerate poor soils, provided they are well-drained. Once the crop has established, it is capable to sustain growth on light sandy soils. Its root system is very deep[11] and it can make use of residual soil moisture. In India and Burma it is often grown on sandy river banks exposed when the monsoon floods subside. The garden cultivars require better conditions. The crop can be grown from sea level up to about 2100 m in tropical Asia. In India cultivars take 6–47 weeks to flower depending on the sowing date (Purseglove, 1968). It is a short-day plant.

It is grown in Ethiopia as a field crop in the Konso region (± 1700–± 1900 m), which has an average annual rainfall of 600–800 mm.

Husbandry

In India the field cultivars are frequently intersown in cereal crops such as *Eleusine coracana* (L.) Gaertn. and are grown as a rain-fed crop in areas with 600–900 mm rainfall annually, needing little care. They are planted in June and July and harvested from October to March. The yield in mixed cultivation is about 450 kg/ha dried seeds, in pure stand up to 1450 kg/ha. The garden cultivars are heavily manured and frequently irrigated. They require support for climbing. They are sown in pits (6–10 seeds per pit) in July or August and are thinned to four vines after one month. They flower in November and the green pods are harvested from December to March. Sometimes the plants are kept for a second year and then begin to yield again in July (Purseglove, 1968).

In the Sudan it is found on flooded land or steep river banks and is either grown alone or with sorghum or maize; it is cut twice, or livestock is tethered or herded in the field. Later a crop of mature beans may be taken and finally the field is grazed. In the riverine areas it is grown in rotation with sorghum and wheat, or with cotton in the Gezira (Whyte et al., 1953).

In El Salvador it serves as a green manure after maize has been harvested, and remains green throughout the dry season of 6 months (Whyte et al., 1953).

Up till now little information is available on the place of this crop in the cultural system, since the culture of lablab is not widespread in Africa. There seems to be an increase of the Indian practice of sowing the crop at the beginning of the rains, using

11. No information has been found in literature on the depth of the root system.

it as hay crop during the rains and harvesting a seed crop some three months after the end of the rains. In areas with two rainfall peaks, it is possible to sow the crop at the beginning of the second rains. It is also capable to grow on irrigated lands. Many of the cultivars are very vigorous and able to suppress weed once well-established; therefore, little weeding is required. If lablab is cultivated as a food crop, heavy foliage growth during the rainy season should be avoided, either by cutting for hay or late sowing. The pods tend to mature in succession on the flowering stem, except with the earliest upright cultivars, in which all pods ripen simultaneously. Although there is less tendency for the seed to shatter than with lima bean, the pods should be harvested as they become ripe (Stanton et al., 1966).

Dolichos lablab appears to be an important legume, the value of which has not been fully exploited for food in Africa. As may be seen from the experiments by Von Schaaffhausen (1963) and others, the crop appears to have considerable value for incorporation in African agriculture (Stanton et al., 1966).

In the Konso region of Ethiopia, lablab is sown mixed with other crops at the onset of the main rains at the beginning of March. The small terraced fields are manured and irrigated as well (Kuls, 1958). Most bean crops are harvested around August, but the author has seen lablab on the fields as late as February. The garden cultivars are climbers and need support. They infrequently occur all over the country below ± 2000 m, but play a minor role. It seems that the plant is more considered an ornamental than as a food crop. Chiovenda (in Atti Soc. ital. Prog. Sci. 17: p. 549 (1928)) already reported that it is not generally cultivated, although wild forms occur throughout the Ethiopian region.

Uses

The young shoots and leaves, the young pods and the ripe seeds are eaten. Moreover, in Indonesia the inflorescence is also used as a vegetable (Heyne, 1927).

Climbing cultivars are a source of green pods and seeds, and the field cultivars as a source of dry legumes. The dry seeds are generally regarded as being highly palatable, but they require lengthy cooking. Some forms contain cyanogenetic glycosides in the raw state (Aykroyd & Doughty, 1964).

Young pods and tender seeds are popular vegetables in India, whereas the ripe and dried seeds are consumed as a split pulse. The seeds are also sprouted, soaked in water, shelled, boiled and made into a paste, which is fried with spices. The seeds can also be eaten roasted, or ground and eaten as delicacies. The haulms, either green or as hay or silage, are used as fodder. The dried seeds as well as unripe pods may be fed to livestock, although some forms contain cyanogenetic glucosides. The growing crop may be grazed and has the valuable property of remaining green in the dry season. It is also grown as a green manure and cover crop (Purseglove, 1968).

In the Konso region of Ethiopia the dry seeds are used in food preparation, but no information is available on the use of this crop in other regions of the country. At any rate it is still an unimportant crop for Ethiopia as a whole.

Protein contents

Leaves: ca 3% (Terra, 1966); young pods: 2.8–3.4% (Terra, 1966), ca 4.5% (Purseglove, 1968); young seeds: 8.3% (Terra, 1966); ripe seeds: 24.9% (Purseglove, 1968), ca 25% (Terra, 1966).

(6) Lathyrus sativus L. (2n = 14) Fig. 9; Plate 12

'*Lathyrus*': Gr. 'lathuros', an ancient Greek plant name probably used for a pulse and possibly even for *Lathyrus sativus*, but not identifiable with certainty.
'*sativus*': derived from the Latin verb 'serere', to sow, to cultivate, which contains 'sat' as its root linguistically, so meaning: that which is sown (or cultivated).

Linnaeus, Sp. Pl. ed. 1: p. 730 (1753).
Type: from Spain and France; '*Lathyrus* pedunculis unifloris, cirrhis ... bimarginatis' (BM, Hort. Cliff., lecto.!).

Synonyms

Cicercula alata Moench, Meth.: p. 163 (1794).
Cicercula sativa Alef., Bonplandia 9: p. 147 (1861); Landw. Fl.: p. 33 (1866).
Lathyrus sativus var. *coeruleus* (Alef.) Asch. & Graeb., Synopsis 6(2): p. 1004 (1910).
Lathyrus abyssinicus A. Braun ex Chiov., Atti Soc. ital. Prog. Sci. 17: p. 548 (1929), nom. nud.
Lathyrus sativus var. *abyssinicus* (A. Braun) Chiov., Malpighia 34: p. 496 (1937), nom. nud.

Literature

1937: Zalkind, in: Vavilov & Wulff, eds, Koultournaja Flora SSSR 4: p. 214-215. (tax.)
1953: Whyte et al., Legumes in agriculture: p. 282-283. (agric.)
1955: Cufodontis, Enumeratio, Bull. Jard. bot. État Brux. 25(2): p. 310. (tax.)
1957: Kuls, Petermanns geogr. Mitt. 101: p. 248-249. (agric.)
1963: Cobley, An introduction to the botany of tropical crops: p. 151-153. (agric.)
1968: Purseglove, Tropical crops, Dicotyl. 1: p. 278-279. (agric.)

Local names: sabberi, with many variations on 'sab' (Tigrinia and Saho); guaya, gwaya, shimbera (Amarinia), gayu (Gallinia).
Trade names: chickling vetch, chickling pea, grasspea (English); gesse blanche (French).

Geographic distribution

Lathyrus sativus is a native of southern Europe and western Asia. It is grown in India, Iran, the Middle East, and southern Europe as well as in parts of Africa and South America (Cobley, 1963).

In Ethiopia it is cultivated in the central Ethiopian Highlands, but it may be found infrequently in other highland regions as well like the Chercher Highlands in Hararge. Seeds have been observed in market places of Tigre and Shoa, but only infrequently in Begemdir, Gojam, Wollo and Hararge.

Description

A much-branched, suberect, glabrous annual with a light brown taproot.

Stems slender, ascending to decumbent, winged.

Stipulae conspicuous, narrowly triangular, with a smaller but equally shaped basal appendage and often with a small tooth between the lobes and sometimes an additional tooth along the margin.

Leaves alternate, 2-foliolate; rachis represented by a simple or branched tendril which is often longer than the petiole. Petiole mostly winged, (1.0–)1.5–2.5(–3.5) cm.

Leaflets entire, almost sessile, narrowly elliptic–oblong, (3.0–)4.0–5.0(–6.5) cm × 3–5(–11) mm, cuneate at base, acuminate to mucronate at top.

Stipellae absent.

Inflorescence axillary, single-flowered; peduncle (1.0–)3.0–3.5(–5.0) cm long; bracts 2, apical, minute. Flowers with a slender pedicel, (2–)5–7(–8) mm long.

Calyx campanulate, glabrous; tube ca 3 mm long; lobes 5, subequal, narrowly triangular, 3–6 mm long.

Corolla: Standard erect and spreading, very broadly obovate, ca 15 × ca 18 mm, finely pubescent at upper margin, clawed, retuse at top, violet-blue with red-purple around a whitish area around and on the twin, central 'pockets'. Wings broadly obovate, ca 14 × ca 8 mm, clawed, auriculate, 'pocketed', obtuse at top, violet-blue to red-purple. Keel slightly twisted, boat-shaped, ca 10 × ca 7 mm, entirely split dorsally, with apical margins denticulate, ventrally split near the base, with the apical part frilled (narrowly winged), clawed, bi-auriculate, 'bi-pocketed', white to purple-tinged.

Androecium: Stamens diadelphous (9 + 1). Vexillary stamen free, ca 9 mm long, basal part (ca 6 mm) winged, apical part (ca 3 mm) more or less filiform and very slightly winged. Staminal sheath ca 6 mm long, free part of filaments 4–6 mm long. Anthers ellipsoid, ca 0.5 mm long, versatile, yellow.

Disk annular.

Gynoecium: Ovary sessile or nearly so, slender, flat, ca 6 mm long, sparsely puberulous, generally 4-ovulate. Style abruptly upturned, ca 7 mm long, gradually widening to a broadly winged, curved, spathulate, apical part, adaxially bearded below the stigma. Stigma terminal, glandular-papillate.

Pod oblong, bulging over the seeds, laterally compressed, (2.5–)3.0(–3.5) × ca 1.0 cm, with upper margin 2-winged, cuneate to rounded at base, shortly beaked, glabrous, 2–5-seeded.

Seeds wedge-shaped, 4–7 mm in diameter, mostly grey to brown and marbled, sometimes light green or brown. Hilum elliptic. Cotyledons yellow.

Seedling with hypogeal germination, early and low branching. Epicotyl sometimes with some purple. Generally the first two leaves simple. First leaf scale-like and mostly largely fused with 2 lateral scale-like 'stipulae', tri-dentate, at top often the lateral teeth much smaller. Second leaf subulate, at the base connected with the 'stipulae'. Following leaves 2-foliolate, in the beginning without appendaged stipulae.

Taxonomic notes

(1) In Sp. Pl. ed. 1 Linnaeus adopted the diagnosis of *Lathyrus sativus* as stated in his Hort. Cliff. p. 367. In LINN two sheets with *Lathyrus sativus* are present of which only one sheet (905.6) remains (Savage, p. 128), but without the usual reference by number to Sp. Pl. ed. 1. Under these circumstances it is preferable to select one of the two specimens in the Clifford Herbarium (cf. Hort. Cliff. p. 367) as the lectotype of *Lathyrus sativus* L.

(2) According to Zalkind (1937) the Ethiopian grasspea belongs to the proles *abyssinicum* of subspecies *asiaticus*. He distinguishes three varieties, being *addis-abebae*, *coeruleus* (Alef.) Zalk. (with 4 subvarieties) and *rotundato-angularis*. This classification is not practical, however.

The following two seed types have been encountered by the author.

(a) Seeds green to light brown. I designate this taxon as cv. Brown Mekele (based on WP 4026B, WP 7572, WP 7573 and WP 7574).

(b) Seeds marbled. I designate this taxon as cv. Gondar Marble (based on WP 4996, WP 7581, WP 7582 and WP 7583).

(3) Vide Cufodontis (Bull. Jard. bot. État Brux. 25(2): p. 310 (1955): sicut alibi in Aethiopia quoque nutrimenti et ornamenti gratia colitur forma typica et haud raro etiam formae florum colore insignes:

– lusus *coeruleus* (Alef.) Asch. & Graeb. (= *Cicercula sativa* var. *coerulea* Alef., *Lathyrus sativus* var. *coeruleus* Schwfth) ...

– lusus *coloratus* (Ser. ex DC.) Asch. & Graeb. (= *Lathyrus sativus* var. *coloratus* Ser. ex DC., *Cicercula sativa* var. *colorata* Alef.).

(4) The plants raised in fields at Wageningen from seeds collected on Ethiopian market places, do not differ essentially from those collected from fields in Ethiopia. The only appreciable difference noted concerns the variation in length of the peduncle: (1.0–)2.0–3.5(–5.0) cm for Ethiopian raised plants and (0.5–)2.5–6.5(–9.0) cm for plants raised at Wageningen.

(5) The description is based on the following specimens.

Tigre	Mekele market: WP 4026A, WP 4026B; Adi Gudem: J. J. de Wilde 7185; 55 km south of Quiha, in field: J. J. de Wilde 4460; Axum market: Sl 949.
Begemdir	Gondar market: WP 4996, Sl 911; Amussit: J. J. de Wilde 7186; Infranz market: Sl 841.
Gojam	Bahar Dar market: WP 4965; Dejen market: Sl 750.
Wollo	Haik market: Sl 47, Sl 1137; Dese market: WP 4020A, WP 4020B, Sl 1105; Kombolcha market: Sl 966.
Shoa	Debre Zeit market: WP 1942; Addis Abeba market: WP 3024.
Sidamo	Soddo market: WP 4049E.
Hararge	Harar market: WP 56; Hirna market: WP 4005; Asbe Teferi market: Sl 465; Bedessa market: Sl 666; in field 9 km past Bedessa on Gelemso road: WP 3170; Waichu market: Sl 511; College of Agriculture, Alemaya: WP 1905; garden Alemaya: WP 272, WP 742, WP 1195, WP 1804, WP 2218; Karra market: Sl 577.

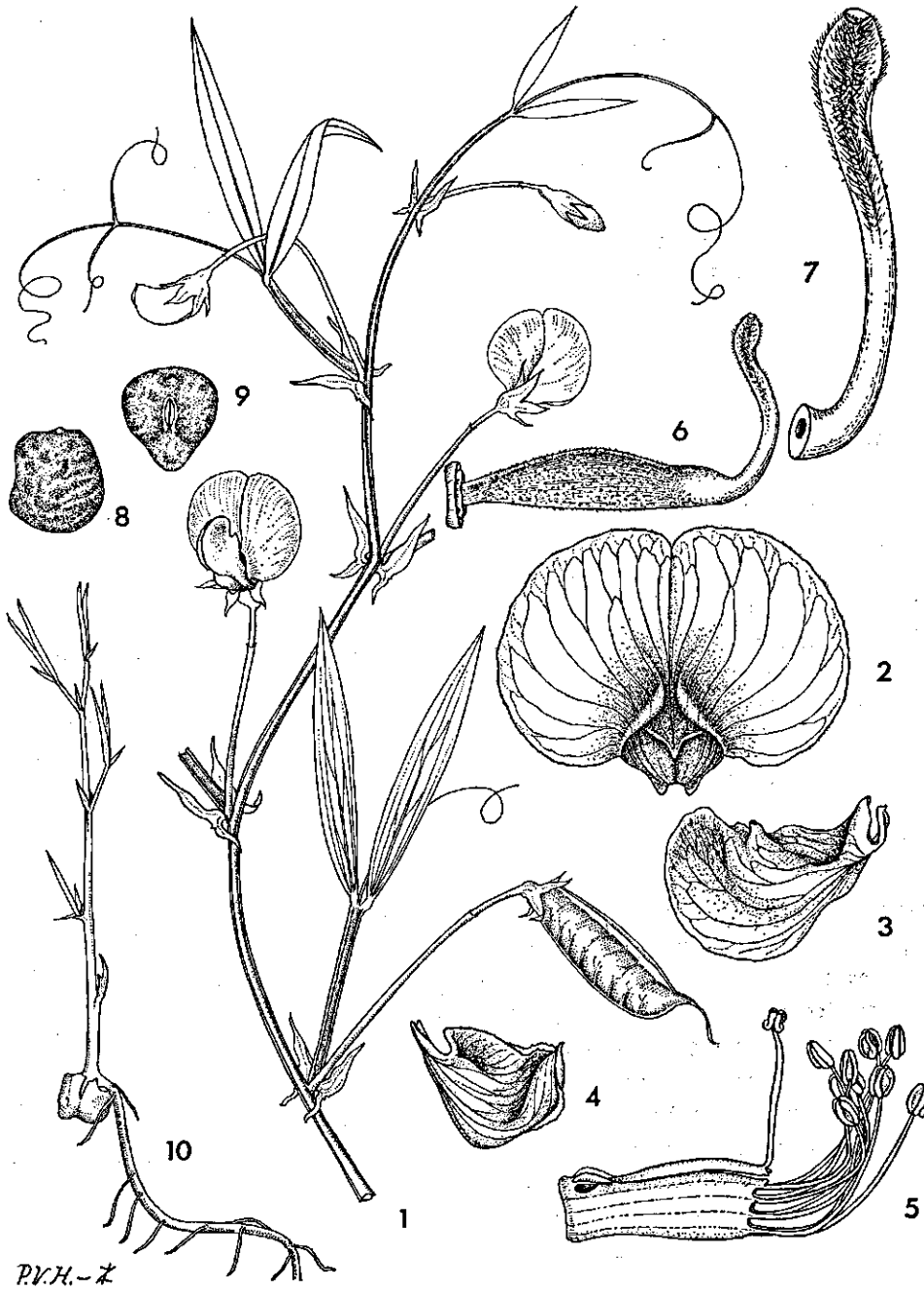

Fig. 9. *Lathyrus sativus* L. cv. Gondar Marble. – 1. branch with leaves, inflorescences and pod (5/6 ×); 2. standard, adaxial view (2½ ×); 3. wing, abaxial view (2½ ×); 4. keel (2½ ×); 5. staminal sheath (5 ×); 6. pistil (5 ×); 7. style + stigma (10 ×); 8. seed (2½ ×); 9. seed, with hilum (2½ ×); 10. seedling (5/6 ×). – 1. WP 7570 (including spirit mat.), WP 7571 (including spirit mat.); 2–7. WP 7570 (spirit mat.); 8–9. WP 4005; 10. WP 7569 (spirit mat.).

Grown at Wageningen WP 5805–WP 5809, WP 6170, WP 6171, WP 7052, WP 7053, WP 7566–WP 7583.

Ecology

Grasspea is grown as an annual crop in the dry season. It is very hardy and will germinate and grow on land too dry for other crops since it is extremely resistant to drought. It tolerates water-logging and a wide range of soil conditions, including poor soils. It is often grown as a catch crop in rice fields, both as a grain crop and as a fodder (Purseglove, 1968).

In Ethiopia is it usually cultivated between ± 1800–± 2000 m altitude, and often in the dry season after the main rains.

Husbandry

The crop is usually broadcast and matures in 5–6 (rarely 4) months. Because of its resistance to drought it has been an important famine crop in India, surviving, or cultivated, after cereals have failed. Yields of ca 1000–1225 kg/ha dry seeds and ca 1350–1575 kg/ha hay are reported (Purseglove, 1968).

In Ethiopia the grasspea usually is sown at the end of the rains in September and is harvested in January/February. In the Yerer-Kereyu Highlands it serves to restore soil fertility on land fallowed during nine months of the year. Sometimes it succeeds another legume with a small interruption, such as pea or chickpea, which has been sown in April and harvested in July (Kuls, 1957).

Uses

Grasspea is grown for fodder and in India and the Middle East the seeds are eaten by the poorer classes, particularly in times of famine. They are boiled and often made into chapaties, paste balls and curries. The seeds are fed to livestock. The leaves serve as a pot herb. Seeds contain an alkaloid and, if not carefully boiled and consumed over a long period, can cause the disease known as lathyrism, characterized by a paralysis of the lower limbs. Small quantities, equal to the usual daily intake of legumes in general, seem to be harmless. Outbreaks of the disease are the result of near-famine conditions which deprive people of their accustomed cereal and force them to rely too heavily on grasspea (Aykroyd & Doughty, 1964; Purseglove, 1968).

In Ethiopia seeds are consumed roasted and are used in the preparation of 'wot". The crop is not highly esteemed, but is used as fodder crop.

Protein content

Leaves: ca 6% (Terra, 1966); ripe seeds: 23.4% (Darby et al., 1959), ca 27% (Terra, 1966).

(7) Lens culinaris Med. Fig. 10; Plate 13

'*Lens*': Latin name for a disc-shaped ('lens-shaped') object. In the course of time applied to very different taxa but always indicating a lens-shaped seed.
'*culinaris*': derived from the Latin 'culina', a kitchen, or what is proper to a kitchen, viz food; 'culinaris' signifies 'what is edible', or a food, or what is being eaten.

Medikus, Vorles. Churpf. Phys. Ges. 2: p. 361 (1787).
Type: habitat inter Galliae segetes; '*Ervum* seminibus compressis convexis' (LINN, specimen 907.1 excluding the specimen from Herb. Jacq., lecto.!).

Synonyms

Ervum lens L., Sp. Pl. ed. 1: p. 738 (1753) (basionym).
Lens esculenta Moench, Meth.: p. 131 (1794).
Vicia lens Coss. & Germ., in: Fl. env. Paris 1: p. 143 (1845).
Ervum lens var. *abyssinica* Hochst. ex Rich., Tent. Florae Abyss. 1: p. 196 (1847).
Lens esculenta var. *abyssinica* Alef., Bonplandia 9: p. 131 (1861).
Lens esculenta var. *abyssinica* (Hochst. ex Rich.) Engler, Ueb. Hochgeb. Flora trop. Afrika: p. 265 (1892).
Lens culinaris var. *abyssinica* (Hochst. ex Rich.) Chiov., Malpighia 34: p. 496 (1937).
Vicia lens var. *abyssinica* (Hochst. ex Rich.) Fiori, Agricoltura colon. 33: p. 427 (1939).
Lens abyssinica A. Br. ex Chiov., Atti Soc. ital. Prog. Sci. 17: p. 548 (1929).
For more synonyms see Barulina in Bull. appl. Bot. Genet. Pl. Breed., Suppl. 40: p. 59 (1930).

Literature

1930: Barulina, Bull. appl. Bot. Genet. Pl. Breed., Suppl. 40: p. 1-307. (tax.)
1951: Vavilov, Chronica bot. 13(1-6): p. 38. (breed.)
1955: Cufodontis, Enumeratio, Bull. Jard. bot. État Brux. 25(2): p. 308–309. (tax.)
1957: Kuls, Petermanns geogr. Mitt. 101: p. 249. (agric.)
1960: Simoons, Northwest Ethiopia: p. 109-110. (agric.)
1964: Aykroyd & Doughty, Legumes in human nutrition: p. 117. (agric.)
1968: Purseglove, Tropical Crops, Dicotyl. 1: p. 279-281. (tax. + agric.)
1972: Saint Clair, Responses of Lens esculenta Mo. to controlled environmental factors, Meded. LandbHogesch. Wageningen 72(12): p. 72-73. (agric.)

Local names: burssum (Tigre); bersem with variations on 'bers' (Tigrinia); birssin, manssir (Saho); messer, messere, misser, ades (Amarinia); messiri, messire (Gallinia).
Trade names: lentil, common lentil (English); lentille (French).

Geographic distribution

The lentil is one of the oldest pulse crops and is of ancient cultivation in western Asia, Egypt and southern Europe. From these areas the crop spread eastwards to India and through much of China, southwards to Ethiopia, and northwards in Europe (Purseglove, 1968). The ancientness of lentil cultivation in south-western Asia is testified by numerous Sanskrit names. It is now widely cultivated in temperate and subtropical regions, as well as at higher elevations in the tropics where it is grown in the coldest season of the year. It occurs in the Mediterranean area, in Europe, Russia,

north Africa, south-western Asia, India, China, and in South America (Chile, Argentine, etc.). It is of special importance in northern India and Pakistan where it is grown up to ca 3400 m (Purseglove, 1968; Saint Clair, 1972).

In Ethiopia it is mainly found in the central Ethiopian Highlands, but it is also cultivated in other regions of the country. In most visited markets seeds have been observed.

Description

A much-branched, suberect, slightly pubescent, light green annual; taproot slender.

Stems small, square (angles ribbed), with several basal branches.

Stipulae small, narrowly triangular to obliquely rhomboid, entire, without basal appendage.

Leaves alternate, pinnate, with (5–)8–12(–15) leaflets; petiole short; rachis (1.0–) 2.5–3.5(–4.5) cm long, produced into a simple (sometimes dichotomous) tendril, longer in upper leaves (sometimes as long as the rachis), and sometimes with a leaflet-like top.

Leaflets opposite or alternate, subsessile, narrowly obovate–elliptic, (8–)10–15(–18) × 2–5 mm, entire, cuneate at base, rounded to acute at top.

Stipellae absent.

Inflorescence an axillary raceme (1–3 flowers); peduncle slender, (2.0–)3.0–4.0(–5.5) cm long; rachis ending into a filiform apex; bracts absent; pedicels short.

Calyx campanulate; tube ca 1.5 mm long; lobes 5, subequal, linear–triangular, ca 3 mm long.

Corolla small. Standard approaching the keel, hood-shaped, broadly obovate, ca 5 × ca 4 mm, clawed, obcordate and mucronate at top, light violet-blue. Wings oblong–obovate, ca 4.5 × ca 1.5 mm, with a long claw, auriculate, 'pocketed', adherent to the keel, obtuse at top, white, tinged light violet-blue. Keel ladle-shaped, ca 4.5 × ca 2 mm, entirely split dorsally, ventrally split near the base, clawed, bi-auriculate, bi-'pocketed', white.

Androecium: Stamens diadelphous (9 + 1). Vexillary stamen free, ca 3.5 mm long, gradually winged towards the base. Staminal sheath ca 2.5 mm long when on either side the first filament is released; as a rule this is followed by one pair of stamens, followed again by a single stamen, and then ending by the top stamen. Anthers basifixed, approx. spherical, ca 0.2 mm in diam., light yellow.

Disk annular.

Gynoecium: Ovary subsessile, laterally compressed, ca 3 mm long, sparsely puberulous, 2-ovulate. Style abruptly upturned, ca 1.5 mm long, somewhat flattened, glabrous, bearded adaxially below the stigma. Stigma: the slightly swollen, glandular-papillate ending of the style.

Pod oblong, laterally compressed, bulging over the seeds, ca 13 × ca 6 mm, rounded to slightly cuneate at base, short-beaked, glabrous, 1–2-seeded.

Seeds lens-shaped, ca 4 mm in diam., either grey-brown with black spots (or

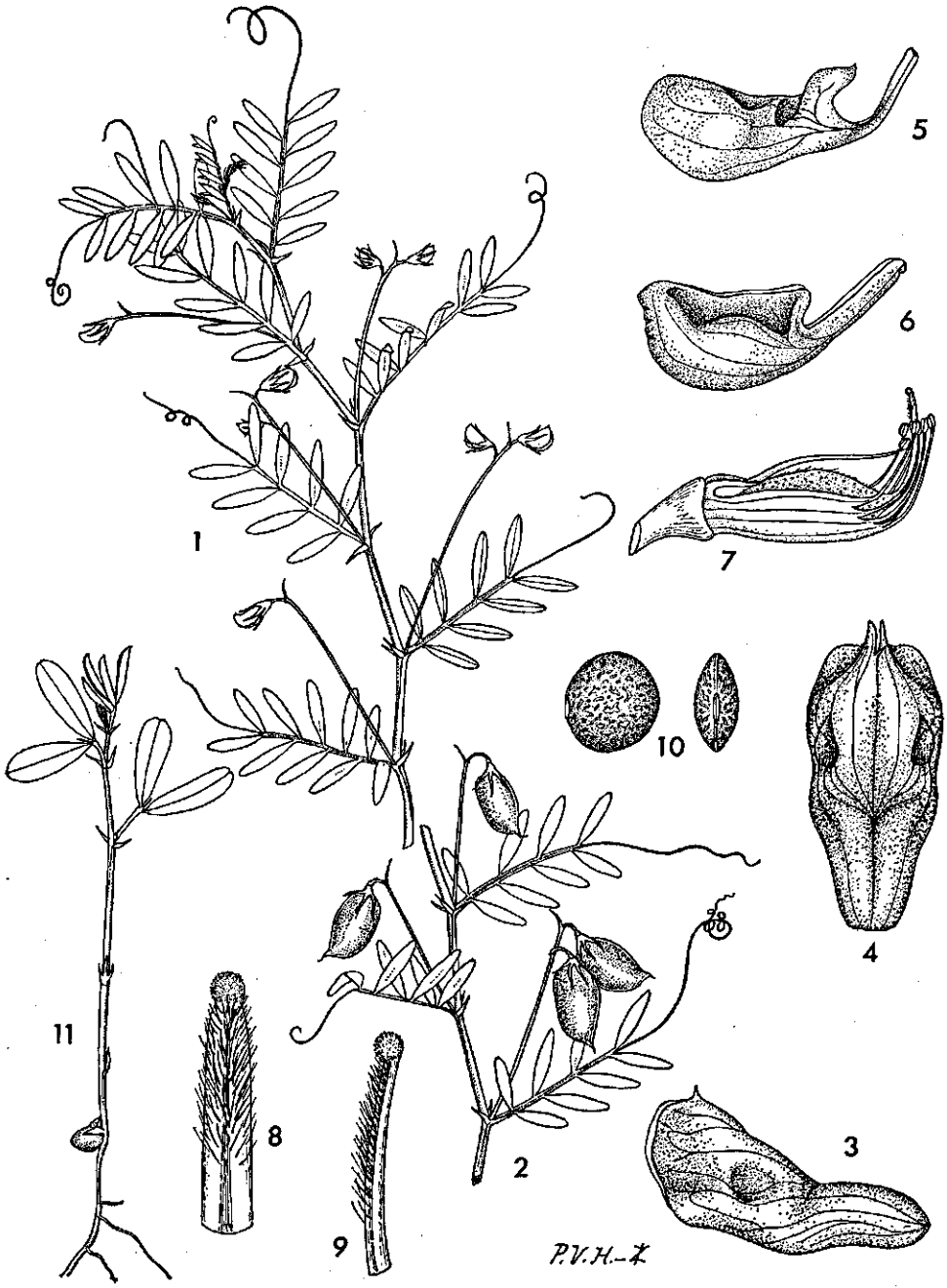

Fig. 10. *Lens culinaris* Med. cv. Copticum. – 1. branch with leaves and flowers (5/6×); 2. branch with leaves and pods (5/6×); 3. standard, side view (7½×); 4. standard, abaxial view (7½×); 5. wing, abaxial view (7½×); 6. keel (7½×); 7. staminal sheath and pistil (7½×); 8. style + stigma, adaxial view (30×); 9. style + stigma, side view (30×); 10. seeds (2½×); 11. seedling (5/6×). – 1. WP 7616; 2. WP 7617; 3–9. WP 7616 (spirit mat.); 10. WP 2816A; 11. WP 7615 (spirit mat.).

marbled), or grey-black with brown spots (or marbled), smooth or wrinkled. Hilum narrowly elliptic, minute. Cotyledons orange.

Seedling with hypogeal germination. Epicotyl sometimes purplish. First two leaves simple, scale-like and largely fused with two lateral scale-like 'stipulae'. Top first leaf acute, sometimes with two minute lateral teeth; top second leaf tri-dentate, often the lateral teeth smaller. Generally the following two leaves 2-foliolate.

Taxonomic notes

(1) In Hort. Cliff. p. 370 Linnaeus placed the lentil in the genus *Cicer*, being '*Cicer* pedunculis bifloris, seminibus compressis ... Folia integerrima, ovato-oblonga; semina orbiculata, compressa, utrinque convexa'. In Sp. Pl. ed. 1 Linnaeus placed the lentil in the genus *Ervum*. In both cases the concept of this taxon is the same; consequently the specimens in the Clifford Herb. as well as in LINN are suitable for selection of the lectotype. In LINN 2 sheets (907.1, 907.2) are present of which the first bears the reference by number to Sp. Pl. ed. 1. At the right hand bottom a specimen is attached from the Herb. Jacquin with larger seeds. I prefer to designate LINN 907.1 (excluding the specimen from Herb. Jacquin) as the lectotype of *Lens culinaris* Med.

(2) Linnaeus (1753) brought the lentil to the genus *Ervum* L. (*Ervum lens* L.) together with *E. tetraspermum. E. hirsutum, E. monanthos* and *E. ervilia.* The last 4 species are now headed under the genus *Vicia* L. Accepting *Lens* P. Miller as well as *Vicia* as separate genera, *Ervum* has to be regarded as a section of the genus *Vicia.* Since *Lens culinaris* has been validly published by Medikus in 1787, this name has priority over *Lens esculenta* published by Moench in 1794.

(3) Alefeld (1866) established eight varieties within the species *Lens esculenta.* Barulina (1930) concludes that this classification does not embrace the whole diversity of lentil forms, and she comes to 58 varieties. This classification is chiefly morphologic-geographic, based in the first place on the geographic principle. All forms of the lentil may be classified in two vast geographic groups, morphologically well delimited, each with a definite geographic area: ssp. *macrosperma* (Baumg.) Barul. and ssp. *microsperma* (Baumg.) Barul. The small-seeded lentil is more polymorphous than the large-seeded one.

Within ssp. *microsperma* six narrower geographic groups of varieties (grex varietatum) may be marked out. Each of them is distinguished by an complex of morphological characteristics common to all its varieties and not repeated in other groups. At the same time each group is differentiated geographically. The varietal characteristics are partly non-geographic; they show comparatively little variation due to environmental conditions (which is very convenient for identification) and partly designate economical peculiarities such as colour of the seed coat and the cotyledons, colour of the pods, and the shape of the plant. For Ethiopia Barulina recognized two varieties: var. *abyssinica* (Hochst.) Al. with greyish-reddish seeds with black spots, and var. *copticum* Barul. with black seeds, both belonging to grex *aethiopicae* Barul.

The last is cultivated along with var. *abyssinica*, usually as an admixture.

The lentil forms grown in Ethiopia and Yemen are restricted to this region. With regard to many characteristics (flowers small, violet-blue, calyx teeth shorter than the corolla, seeds small, dwarfiness, earlyness) they (grex *aethiopicae*) are akin to those in India and Afghanistan, but they may be easily distinguished from them by their general habitus. Studies of Barulina have shown that the Abyssinian lentil, when crossed with the Afghan and Middle-Asiatic forms, remains partly sterile, a fact which proves its individuality (Vavilov, 1951).

The following cultivars are recognized.

(a) Seeds greyish with black spots. I designate this taxon as cv. Abyssinica (based on WP 4994, WP 7624, WP 7625 and WP 7626).

(b) Seeds black. I designate this taxon as cv. Copticum (based on WP 2816A, WP 7615, WP 7616 and WP 7617).

(4) The material collected by the author agrees with the description Barulina gives of the seeds of var. *abyssinica* and var. *copticum*. The plants raised at Wageningen do not differ essentially from the specimens grown in Ethiopia, except that the seeds are slightly smaller. Plants raised from grey-black seeds produced F_1-seeds of a marked black colour.

(5) The description is based on the following specimens.

Eritrea	Adi Caier market: Sl 875.
Tigre	Axum market: Sl 933, Sl 934; Adi Shoa market: Sl 1042.
Begemdir	Gondar market: WP 4994, Sl 916.
Wollo	Kombolcha market: Sl 965; Bati market: Sl 1042; Dese market: Sl 1104; Haik market: Sl 1136.
Shoa	5 km north of Addis Abeba, naturalized: W. J. de Wilde 5950; 30 km past Addis Abeba on Dese road, naturalized: W. J. de Wilde 10925; Robi market: Sl 1149, Sl 1150; Kuyera market: Sl 1193; Kolito market: WP 2861A, WP 2861B.
Kefa	Jima market: WP 3281A, WP 3281B; Agaro market: Sl 95.
Sidamo	Dila market: WP 2816A, WP 2816B.
Bale	Goba market: Sl 1225.
Arussi	Sire market: Sl 148.
Hararge	Dire Dawa market: WP 116A, WP 116B; Alemaya market: WP 16A, WP 16B; Harar market: WP 39A, WP 39B, WP 87A, WP 87B, WP 87C; garden Alemaya: WP 223, WP 224, WP 247, WP 248, WP 303, WP 304, WP 344, WP 345, WP 730, WP 734, WP 760, WP 1058, WP 1061, WP 1062, WP 1069, WP 1070, WP 1189, WP 1198, WP 1199, WP 1784, WP 1785, WP 1797, WP 1828; foothills of Gara Muletta Mts, in field: J. J. de Wilde 5825; Jijiga market: Sl 352; Feddis market: Sl 175, Sl 184; Langhe market: Sl 198, Sl 287; Deder market: Sl 389; Bedeno market: Sl 316; Ch'elenko market: Sl 246; Moulou market: Sl 442; Bedessa market: Sl 667; Karra market: Sl 576; K'uni market: Sl 541; Gelemso market: Sl 622; Waichu market: Sl 512; Asbe Teferi market: Sl 464; Assebot market: Sl 697.
Grown at Wageningen	WP 5637–WP 5642, WP 5723–WP 5727, WP 5915–WP 5918, WP 6027–WP 6031, WP 6638–WP 6643, WP 6744–WP 6747, WP 7605–WP 7626.

Ecology

Lentils are grown as an annual crop in the coldest season of the year throughout the subtropics and in some parts of the tropics. It is found from sea level to 3300 m. They are adapted to a wide range of soils, from light loams to black cotton soils and tolerate moderate alkalinity. It is a quantitative long-day plant with some cultivars tending to day-neutral. They are not suited to the hot wet tropics (Purseglove, 1968).

Husbandry

In India the crop is grown in mixed cultivation. When grown in pure stands it is either broadcast or planted. It matures in (3.5–)5–6 months. Yields range from 600–1200 (± 1700 with irrigation) kg/ha (Purseglove, 1968).

In acreage it is the second pulse crop of Ethiopia, surpassed only by the chickpea. Cultivation is limited to the higher regions. In Begemdir and Simen lentils are grown in fields throughout the temperate woyna daga up to 2700 m. They are sown in June and harvested in October, though in the dry season they are sometimes planted on irrigated fields. Lentils are harvested by pulling the plants from the ground. They are then dried in piles and threshed with sticks or with oxen (Simoons, 1960). In the Yerer-Kereyu Highlands lentils are grown from April–July or from September–December (Kuls, 1957). Average yields of ± 600 kg/ha are recorded for Ethiopia.

Uses

The seeds are mainly used to prepare soups. In India the split seeds ('dhal') are used in soups, and the young pods serve as a vegetable. Flour from the ground seeds is mixed with cereals in cakes and is also used as invalid and infant food. The whole plant, whether in the green or dry state, provides excellent fodder (Purseglove, 1968).

In Ethiopia lentil is used in the preparation of 'wot".

Protein content

Ripe seeds: 24.2 % (Darby et al., 1959), ca 25 % (Purseglove, 1968).

The first limiting amino acids are methionine and cystine, followed by tryptophan (Aykroyd & Doughty, 1964).

(8) Lupinus albus L.

'*Lupinus*': ancient Latin designation, derived from lupus = wolf, so: that which is proper to a wolf, goes with a wolf, meaning suspect and of low value; in this case 'lupinus' was a plant providing food for the underdog.
'*albus*': Latin: white (not glossy, dull).

Linnaeus, Sp. Pl. ed. 1: p. 721 (1753).
Type: sine loco; '*Lupinus* calycibus alternis inappendiculatis; ... tridentato' (BM, Hort. Cliff., lecto.!).

(8A) cv.-group Albus

Figs 11, 12; Plate 14

Synonyms

Lupinus termis Forsk., Fl. Aeg.-Arab.: p. 131 (1775).
Lupinus prolifer Desr., in: Lam., Encycl. 3: p. 622 (1789).
Lupinus albus var. *termis* (Forsk.) Alef., Landw. Fl.: p. 80 (1866).
Lupinus albus ssp. *termis* (Forsk.) Caruel, in: Fl. Ital. 10: p. 11 (1893).
Lupinus albus ssp. *albus* (L.) Chamb., in: Flora of Turkey 3: p. 38 (1970).

Literature

1924: Gams, in: Hegi, Illustr. Flora (4)3: p. 1151-1154. (tax. + agric.)
1953: Whyte et al., Legumes in agriculture: p. 288-290. (agric.)
1955: Cufodontis, Enumeratio, Bull. Jard. bot. État Brux. 25(2): p. 242. (tax.)
1963: Cobley, An introduction to the botany of tropical crops: p. 160-161. (tax. + agric.)
1963: Kuls, Frankf. Geogr. Hft 39: p. 45. (agric.)
1966: Plitmann, Israel J. Bot. 15(1): p. 26-27. (tax.)
1970: Chamberlain, in: Davis, ed., Flora of Turkey 3: p. 38-39. (tax.)
1970: Gladstones, Fld Crop Abstr. 23(2): p. 123-148. (agric.)

Local names: gubto (Amarinia); gebto, gibto (Amarinia, Tigrinia).
Trade names: Egyptian lupin (English); termis (Arabic in Egypt); lupin (French).

Geographic distribution

The genus *Lupinus* constitutes a large taxon with more than hundred species of mainly annual herbs distributed throughout the north temperate region of the world, with a few species extending into the tropics. Many lupins are ornamental garden plants, but a few of the large-seeded species are cultivated in the Mediterranean region, throughout north Africa and in the Nile valley. Some are indigenous to North and South America, but the agriculturally important species all spread from the Mediterranean centre, and are mostly used as cover crop or for soil improvement. The white lupin and the Egyptian lupin (both *L. albus*) are the most commonly cultivated types resembling each other closely. The latter is the commoner in the tropics, the former is unsuitable for the tropics but may still be grown in the warm subtropics. The white lupin is found in the Mediterranean and central Europe and was cultivated by the ancient Romans as a source of legume seeds. Egyptian lupin particularly is found in the eastern and southern part of the Mediterranean and as well in the Sudan and Ethiopia. In the Sudan it is grown on flooded lands that are too heavy or saline for other crops (Cobley, 1963; Whyte et al., 1953).

In Ethiopia the cultivation of *L. albus* is limited to Gojam, Begemdir and Tigre, but it is found mainly in Gojam. Seeds have been encountered in the market of Bahar Dar, but may be found in other places of the region as well.

Description

An erect, branched, bushy, pubescent annual (or short-lived perennial). Taproot heavy with globular–ellipsoid nodules.

Stems terete, becoming slightly woody with age, much-branched; internodes of older stems hollow, light green, sometimes purple.

Stipulae subulate to narrowly triangular, filiform at top, entire at edge, white, partly adnate to base of petiole, sometimes for more than 1 cm.

Leaves alternate to more or less opposite, digitate ((5–)7-foliolate). Petiole (3.5–)4.5–7.0(–12.0) cm long.

Leaflets short-petioluled, (sometimes broadly) obovate, (2.0–)3.5–4.5(–6.0) × (0.5–)1.0–1.5(–2.0) cm, entire, with lateral nerves widely spaced, slender and not prominent, tapering towards the base, rounded and mucronate at top, smooth and glabrous or nearly so above, (sometimes velvety) pubescent beneath.

Stipellae absent.

Inflorescence a terminal raceme (flowers numerous, alternate), (3.5–)5.0–8.0(–20.0) cm long, very shortly peduncled; pedicels less than 0.5 cm long, subtended by a usually dedicuous bract; 0–2 bracteoles attached to calyx or partly connate, subulate.

Calyx gibbous dorsally, two-lipped, strongly pubescent outside; tube ca 4 mm long; dorsal lip ca 5 mm long, bi-dentate; ventral lip 5–10 mm long, 3-dentate; lateral teeth smaller.

Corolla: Standard erect and spreading (margins partly reflexed), obovate, (15–)17(–18) × (8–)10(–12) mm, clawed, glabrous or nearly so, bi-'pocketed' ('pockets' elongate), with broadly rounded top and sometimes slightly mucronate, white with violet-blue. Wings obovate, (13–)15(–17) × (6–)8(–10) mm, clawed, glabrous, auriculate, with several parallel rows of minute 'pockets' above the auricle, rounded at top, white to violet-blue, ventrally coherent near the top. Keel ladle-shaped, (12–)14(–15) × ca 4 mm, clawed, entirely split dorsally, ventrally split near the base, bi-auriculate, glabrous, white.

Androecium: Stamens monadelphous, joined into a closed tube, (7–)8(–9) mm long; free part of filaments as a rule alternately long and short; when long (3–)4.5(–6) mm long, slightly winged, anthers globular, basi-dorsifixed, less than 0.5 mm in diam.; and when short (2.5–)(3(–4) mm long, slightly winged and more slender, anthers ellipsoid, basifixed, 1.5(–2) mm long, pale yellow.

Disk absent.

Gynoecium: Ovary sessile, ca 6 mm long, appressed silky, ca 5-ovulate. Style curving upwards, ca 7.5 mm long, glabrous, with a ring of hairlets immediately under the stigma. Stigma small, being the swollen, glandular-papillate ending of the style.

Pod narrowly oblong, laterally compressed, bulging over the seeds, (7.5–)8.5–9.5(–11.0) × 1.5–2.0 cm, attenuate at base, beaked, glabrescent, (3–)5(–6)-seeded.

Seeds rectangular–square with rounded corners, laterally compressed, 9–14 × 8–12 mm, sometimes wrinkled, cream. Hilum at one corner, small, sunken, elliptic, (light) yellowish. Cotyledons light yellowish.

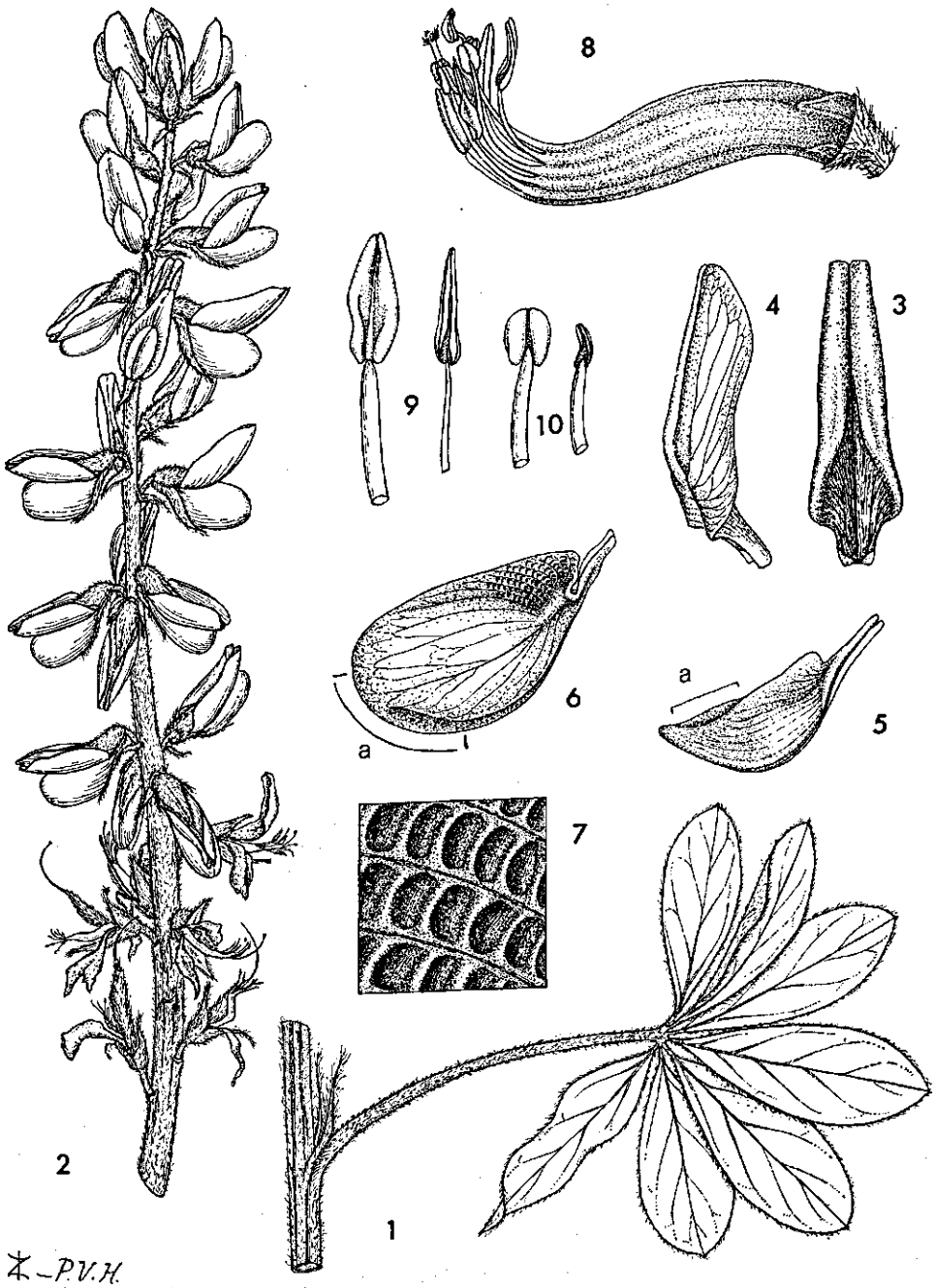

Fig. 11. *Lupinus albus* L. cv. Bahar Dar. – 1. leaf (5/6×); 2. inflorescence (5/6×); 3. standard, adaxial view (2½×); 4. standard, side view (2½×); 5. keel, dorsal edges partly adherent (a) (2½×); 6. wings, ventral edges partly adherent (a) (2½×); 7. wing, detail of 'pockets', abaxial view (25×); 8. staminal sheath (5×); 9. anthers ellipsoid, basifixed (7½×); 10. anthers globular, basi-dorsifixed (7½×). – 1–2. WP 7521; 3–10. WP 7518 (spirit mat.).

Seedling with epigeal germination. Cotyledons sessile or nearly so, fleshy, transversely elliptic and curved, (17–)19(–22) mm long, (15–)20(–21) mm wide, cuneate at base, dorsal part dark green, ventral part light green. Hypocotyl green, frequently with purplish spots.

Taxonomic notes

(1) In Sp. Pl. ed. 1 Linnaeus referred to Hort. Cliff. p. 499 and 359, taking over the diagnosis of this taxon in Hort. Cliff. p. 499. Under these circumstances it seems preferable to designate one of the two specimens in the Clifford Herb. (cf. Hort. Cliff. p. 359), the one being slightly composite ('*Lupinus* caule composito'), as the lectotype of *Lupinus albus* L.

(2) Forskål (1775) gives for *Lupinus termis* the following description: 'Calycibus alternis, appendiculatis, labio utroque integro, acuto. Caulis 5-pedalis, hirsutus. Folia digitata, quina, sena. Foliola oblonga, obtula, extriorsum latiora; subrus hirsutus, supra glabra, sesquipoll. Flores in racemo terminali, alterni, albi vel caerulei. Pedunculi villosi. Calyx villosus, appendice filiformi, ferruginei coloris. Carinae apex caeruleo-viridis'.

Alefeld (1866) considers *L. termis* as a variety of *L. albus* L. He than distinguishes between *L. albus* var. *vulgaris* Alef. (flowers without bracteoli; keel, including tip, white; upper and lower surface of leaf pubescent), and var. *termis* (Forsk.) Alef. (flowers with bracteoli attached to calyx; tip keel blue; lower surface of leaf pubescent).

Ascherson & Graebner (1910) distinguish two species, *L. albus* and *L. termis*, and considered them to be closely related. The latter seems to differ from the former only in having bracteoles, but the authors question the importance of this characteristic.

Gams, in: Hegi (1924) considers both lupins to belong to *L. albus* with two (not sharply distinguishable) varieties: var. *vulgaris* (the most widely spread taxon) and var. *termis* (the Sicilian or Egyptian lupin with smaller bracts and found in the south-eastern part of the Mediterranean).

It appears that the presence or absence of bracteoli attached to the calyx, which played an important role for Linnaeus (1753) in distinguishing the *Lupinus* species as well as in Forskål's analysis of *L. termis*, is not that important. Moreover, in *L. albus* bracteoles may actually be present, but they are very soon deciduous (Plitmann, 1966). In Ethiopia specimens were collected by the author, as well as those raised at Wageningen from seeds collected in that country, which showed either two bracteoli per flower, or none (with no scars observed). Most remarkably, at the calices of a single plant collected by F. G. Meyer (nr 8664) in Ethiopia, 0, 1 or 2 bracteoles were found (again with no scars observed). Since the main difference between the two taxa as mentioned in the older literature, being the presence or absence of bracteoli, is not really a differentiating characteristic, and is found in both taxa, it is concluded that both belong to *L. albus*. In modern literature the presence or absence of bracteoli has indeed hardly been mentioned anymore. Plitmann maintains *L. albus* cv.-group Albus and *L. termis* as separate taxa, the former being adpressed–pilose with short racemes

and entirely white, alternate flowers, the latter being patulous–villous with long racemes and remotely whorled, blue-tipped, white flowers. But these differences are not clear-cut and do not deserve specific or subspecific rank, the more so as transitional forms have been observed by Plitmann in European herbaria. The morphological overlap between these two taxa is considerable and it seems reasonable to reduce *L. termis* to a synonym of *L. albus* cv.-group Albus as advocated by Chamberlain (1970).

(3) I designate the lupin collected in Ethiopia as cv. Bahar Dar (based on WP 4964, WP 7523, WP 7525 and WP 7526).

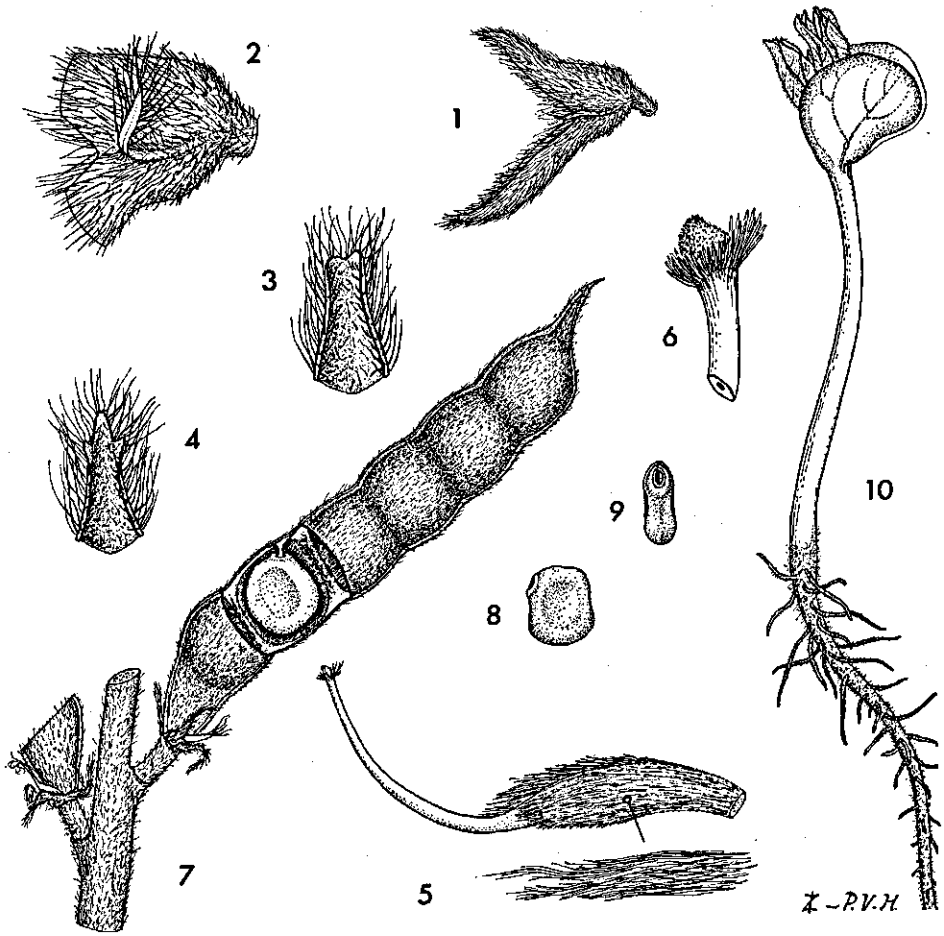

Fig. 12. *Lupinus albus* L. cv. Bahar Dar. – 1. calyx with bracteole (2½×); 2. idem (5×); 3. calyx, dorsal lip (7½×); 4. calyx, ventral lip (7½×); 5. pistil (5×), with detail hairs on ovary (ca 7½×); 6. stigma (25×); 7. pod (⅚×); 8. seed, lateral view (⅚×); 9. seed, with hilum (⅚×); 10. seedling (⅚×). – 1–6. WP 7518 (spirit mat.); 7. WP 3112; 8–9. WP 4964; 10. WP 7519 (spirit mat.).

(4) The following differences were found between plants raised at Wageningen and in Ethiopia:

	Wageningen	Ethiopia
petiole	3.8–12.0 cm	3.9–7.0 cm
leaflet: length	2.5– 5.8 cm	2.3–5.0 cm

(5) The description is based on the following specimens:

Gojam	Bahar Dar market: WP 4964; 15 km past Bahar Dar on Gondar road, in field: F. G. Meyer 8664.
Shoa	Debre Zeit Exp. Station, seeds from Gojam: WP 4902.
Arussi	Kulumsa farm, 8 km past Asella on Nazret road: WP 3112.
Hararge	Collection Taddesse Ebba, College of Agric., Alemaya, seeds from Gojam: WP 4956.
Grown at Wageningen	WP 7516–WP 7526.

Ecology

In regions of higher latitudes lupins are grown in the warmest season of the year; in the subtropics and tropics in the coldest season (Whyte et al., 1953). *Lupinus albus* cv.-group Albus requires a cool to moderately warm growing-period and it is fairly tolerant to night frost. The exact temperature ranges, however, are not known. In the most successful lupin growing areas at least five months are free from serious moisture shortages and, during this period the mean monthly maximum temperatures are between 15° and 25 °C. It prefers mildly acid to slightly calcareous loamy sands and loams, but it cannot stand water-logging. All Mediterranean lupin species are long-day plants (Gladstones, 1970).

In Ethiopia *Lupinus albus* cv.-group Albus is found in the woyna daga region (1800–2400 m), especially in Gojam.

Husbandry

It grows well on the Nile banks on soils that are too saline or too heavy for other crops (Cobley, 1963; Whyte et al., 1953).

In Gojam (Ethiopia), Egyptian lupin is especially cultivated on soils too poor for a good horse bean crop. In the higher parts of the woyna daga it is grown together with horse bean, pea and barley (Kuls, 1963). It is sown during the main rainy season (July–September) and harvested around December.

Uses

Lupin seeds are slightly poisonous and must be boiled and strained before eating to remove the bitter principle. The fodder can be fed to stock, but care must be taken for overfeeding as this may result in lupinosis. The toxicity of the plant appears to vary

with age and environment, both affecting the quantity of alkaloids (lupinine and lupinidine), common in the cultivated species. Breeding work has resulted in 'sweet' cultivars. *Lupinus albus* cv.-group Albus is still used as human food in parts of southern Europe. The ripe seeds have a bitter taste which is removed by boiling; they are consumed raw with some salt. The main use of the crop now is as a fodder. The seeds of Egyptian lupin are eaten after having been soaked in water for a long time, or cooked in salt water and shelled. Consumption is confined largely to the poorer classes (Aykroyd & Doughty, 1964; Cobley, 1963; Terra, 1966).

In Ethiopia the seeds of Egyptian lupin are eaten in times of food scarcity.

Protein content

Ripe seeds: ca 40 % (Terra, 1966).

(9) Mucuna pruriens (L.) DC.

'*Mucuna*': a Brazilian-Portuguese plant name from Tupi mucuna(n).
'*pruriens*': derived from 'prurire' (Lat.): causing an itch, itching.

De Candolle, Prodr. 2: p. 405 (1825).
Type: Indonesia, Amboina; Rumphius, Herb. Amb. 5: t. 142 (1747) (lecto.!).

Synonyms

Dolichos pruriens L., in: Stickman, Diss. Herb. Amb.: p. 23 (1754); Am. Acad. 4: p. 132 (1759) (basionym).
Stizolobium pruriens Med., Vorles. Churpf. Phys. Ges. 2: p. 399 (1787).
Carpopogon pruriens Roxb., Hort. Beng.: p. 54 (1814).
Mucuna prurita Wight, in: Hook., Bot. Misc. 2: p. 348 (1831).
Stizolobium pruritum Piper, Proc. biol. Soc. Wash. 30: p. 54 (1917).

(9A) Cv.-group Utilis

Fig. 13; Plate 15

'*utilis*': useful (Lat.: utilis).

Burck, Annls Jard. bot. Buitenz. 11: p. 187 (1893), being *M. pruriens* var. *utilis* (Wall. ex Wight) Baker ex Burck.
Type: sine loco; Wight, Ic. Pl. Ind. Or. 1: t. 280 (1840) (lecto.!).

Synonyms

Mucuna utilis Wall. ex Wight, Ic. Pl. Ind. Or. 1: t. 280 (1840) (basionym).
Mucuna velutina Hassk., Cat. Hort. Bog.: p. 277 (1842).
Mucuna pruriens (L.) DC. var. *utilis* (Wall. ex Wight) Baker ex Burck, Annls Jard. bot. Buitenz. 11: p. 187 (1893).
Stizolobium utile (Wall. ex Wight) Piper & Tracy, U.S.D.A. Bur. Plant Ind. Bull. 179: p. 14 (1910).
Mucuna pruriens (L.) DC. f. *utilis* (Wall. ex Wight) Backer, Flora of Java 1: p. 629 (1963).

Literature

1747: Rumphius, Herb. Amb. 5: p. 381, 392-393, t. 138, 142. (tax. + agric.)
1828: Wallich, A Numerical List: p. 193. (tax.)
1879: Baker, in: Hooker, Flora of British India 2: p. 187. (tax.)
1908: Bort, U.S.D.A. Bur. Plant Ind. Bull. 141: p. 25-32. (tax.)
1910: Piper & Tracy, U.S.D.A. Bur. Plant Ind. Bull. 179. (tax. + agric.)
1927: Heyne, Nuttige planten Ned. Indië 2: p. 825-827. (agric.)
1931: Ochse, Indische groenten: p. 396-398. (agric.)
1937: Dittmer, in: Vavilov & Wulff, eds, Koultournaja Flora SSSR 4: p. 390, 393-408. (tax.)
1938: Piper & Morse, U.S.D.A. Fmr's Bull. 1276. (agric.)
1953: Whyte et al., Legumes in agriculture: p. 323-325. (agric.)
1955: Cufodontis, Enumeratio, Bull. Jard. bot. État Brux. 25(3): p. 318. (tax.)
1959: Mansfeld, Vorläufiges Verzeichnis, Die Kulturpflanze, Beiheft 2: p. 202-204. (tax.)
1959: Wit, de, Checklist Rumphius' Herb. Amb., in: De Wit, ed., Rumphius Memorial Volume: p. 390. (tax.)
1964: Aykroyd & Doughty, Legumes in human nutrition: p. 111-112. (agric.)
1966: Burkill, Dict. ec. prod. Malay Peninsula 2: p. 1524-1528. (tax. + agric.)
1966: Terra, Tropical Vegetables: p. 61. (agric.)
1968: Purseglove, Tropical crops, Dicotyl. 1: p. 220. (agric.)
1970: Verdcourt, Kew Bull. 24(2): p. 286-287. (tax.)
1971: Verdcourt, in: Flora Trop. East Africa, Leg. 4, Papil. 2: p. 561, 566-567. (tax.)

Local names: ?
Trade names: velvet bean, Mauritius bean, Bengal (velvet) bean (English).

Geographic distribution

It is probably a native of tropical Asia, and has been widely distributed throughout the tropics. The distribution has recently been extended into the temperate zones by breeding (Whyte et al., 1953).

In Ethiopia seeds of this taxon have been collected once in the market of Gimbi (Wellega). It may be possible that the velvet bean is cultivated in the western fringes of Ethiopia, but information is lacking.

Description

A vigorous, climbing, pubescent annual.

Stems ± terete, slightly pubescent with white, straight, slender, ± appressed downwards, short and long hairs.

Stipulae deciduous, subulate, ± 0.5 cm long, white-hairy (glabrous inside).

Leaves alternate, 3-foliolate. Petiole (3.0–)4.0–9.0(–13.5) cm long, slightly grooved above, as a rule slightly pubescent, with upwardly appressed hairs (pulvinus pubescent). Rachis (0.5–)1.0–2.0 cm long, grooved above, similarly pubescent, topped by a leaflet.

Leaflets: First two leaflets opposite and conspicuously asymmetrical, top leaflet symmetrical and as a rule smaller, with petiolule short and grooved above and

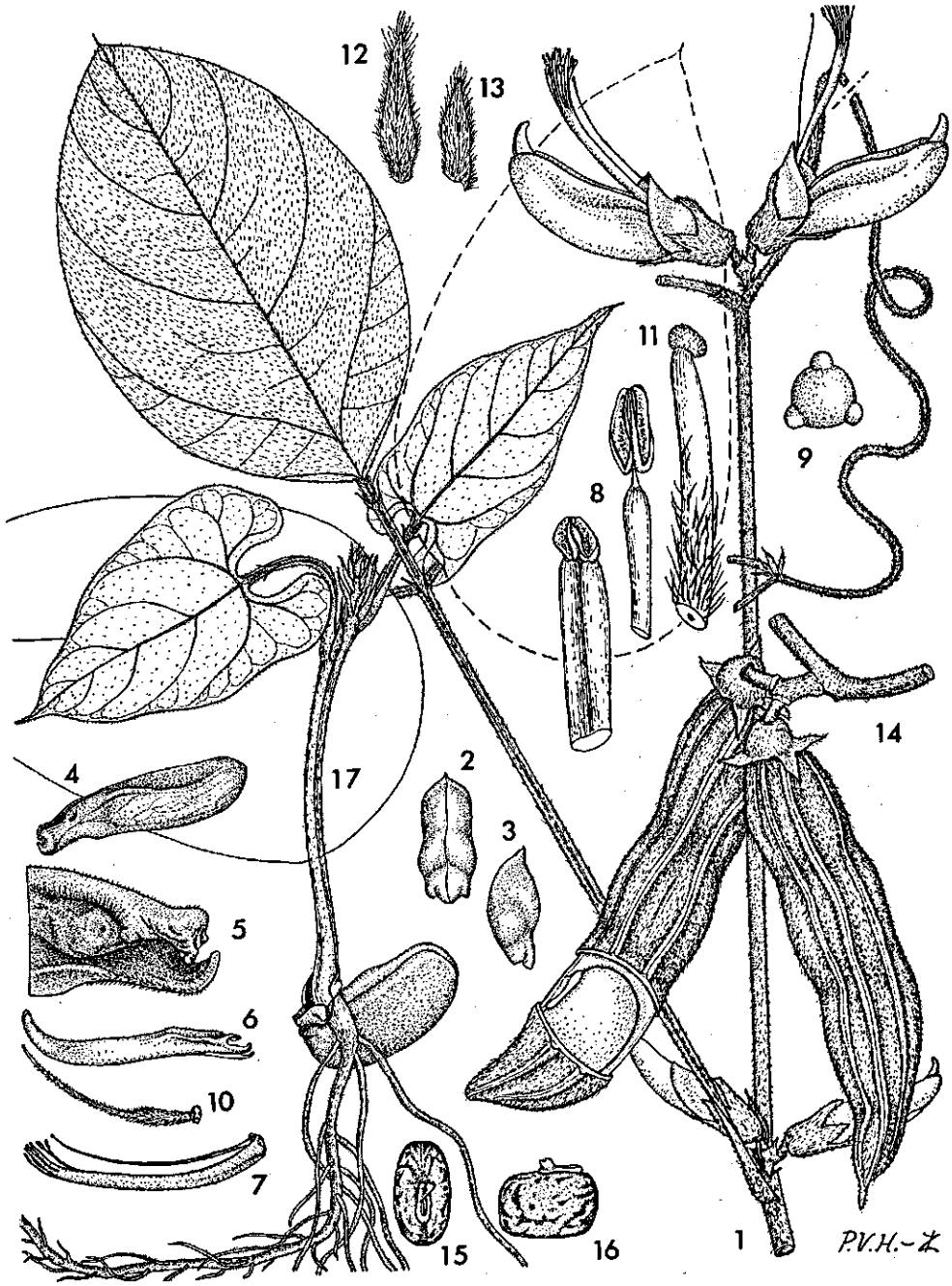

Fig. 13. *Mucuna pruriens* (L.) DC. cv. Velvet Gimbi. – 1. branch with leaf and inflorescence (5/6×); 2. standard, abaxial view (5/6×); 3. standard, side view (5/6×); 4. wing, abaxial view (5/6×); 5. wing, detail basal part, adaxial view (2½×); 6. keel (5/6×); 7. staminal sheath (5/6×); 8. anthers (7½×); 9. pollen grain (130×); 10. pistil + disk (5/6×); 11. style + stigma (10×); 12. bract, lower surface (2½×); 13. stipula, lower surface (2½×); 14. pods (5/6×); 15. seed, with hilum (5/6×); 16. seed, lateral view (5/6×); 17. seedling (5/6×). – 1. WP 8626; 2–11. WP 8626 (spirit mat.); 12–13. WP 8626; 14. WP 8627; 15–16. WP 3385A; 17. WP 7514 (spirit mat.).

(densely) pubescent, (broadly) ovate to elliptic, sometimes rhomboid, (4.0–)6.5–10.5 (–14.0) × (3.0–)4.5–7.0(–8.0) cm, entire, the laterals very oblique, rounded at base, mucronate or sometimes acuminate at top, sparsely pubescent above, young leaves (densely) pubescent with main vein and laterals as well as the edge pubescent, with veins beneath more prominent.

Stipellae small, subulate, glabrous or glabrescent, at the base of the petiolule, 1 per lateral leaflet, 2 per top leaflet.

Inflorescence a supra-axillary raceme, 1–3-flowered. Peduncle short, less than 1 cm long, slightly pubescent, knob-like at top; rachis as a rule reduced to a very small filiform apex; bracts 1 per flower, early deciduous, narrowly triangular–elliptic, 5–10 mm long, long-acute, silvery pubescent at both sides; pedicel short, densely silvery pubescent, with 2 bracteoles attached near the base of the calyx. Bracteoles early deciduous, narrowly triangular, 5–10 mm long, long-acuminate, silverly pubescent.

Calyx campanulate, silvery appressed pubescent outside, inside glabrescent; tube ca 4 mm long; lobes 5, the upper pair of lobes connate forming an entire lip, the other three lobes subequal, (sometimes narrowly) triangular, 4–9 mm long, acute.

Corolla: Standard close to the keel, hood-shaped, much shorter than the other petals, (sometimes broadly) ovate, ca 18 × 11–15 mm, fleshy especially towards the base, shortly clawed, bi-auriculate with auricles small and sometimes inflexed, without 'pockets', rounded at top, glabrous, grey-green to dark purple. Wings narrowly obovate, 32–35 × 8–10 mm, fleshy especially towards the base, clawed, auriculate, with auricle small and inflexed, without 'pockets', rounded at top, finely and patently pubescent at base, especially on ventral edge, dark purple. Keel ca 35 × ca 5 mm, narrow in the middle, clawed, bi-auriculate, entirely split dorsally, ciliolate at edges, glabrescent towards the top, ventrally split near the base and near the top, without 'pockets', with apical part hard, ending in a horny tip, light green, purplish-tinged.

Androecium: Stamens diadelphous (9 + 1). Vexillary stamen free, ca 3.5 cm long, flat; base more fleshy and geniculate. Staminal sheath ca 3 cm long when on either side the first filament is released; this generally is followed by 3 single stamens, after which the top stamen is finally released; free part of filaments alternatingly long and short; the long ones broader and ca 6–7 mm long, with anthers ± globular, dorsifixed, and less than 0.5 mm long; the short ones much more slender, ca 5.5 mm long, with anthers elliptic, basifixed, and 1.0–1.5 mm long. Anthers light brown, with a subulate, strongly constricted filament-apex.

Disk annular; edge slightly wavy.

Gynoecium: Ovary sessile, 7–10 mm long, densely and finely pubescent, ca 4-ovulate. Style curving in the upper half, 15–20 mm long, filiform, finely pubescent, glabrous at top. Stigma capitate, glandular-papillate.

Pod oblong with an oblique top, laterally somewhat compressed, slightly bulging over the seeds, (4.0–)7.0–9.0(–9.5) × ca 1.8 cm, with valves thick with prominent longitudinal ribs, finely pubescent with white to light brown hairs, (1–)3(–4)-seeded. One prominent complete rib on either valve, partial ribs 2–3, less prominent, parallel to the main lateral rib.

Seeds oblong–ellipsoid, somewhat laterally compressed, (12–)15(–18) × (9–)10(–13) mm, light brown with dark brown mosaic. Hilum oblong, lateral, excentric, ca 4 mm long, surrounded by an aril. Aril prominent, white, with a scale-like extension at the rim. Cotyledons dull, pale yellowish.

Seedling with hypogeal germination. Taproot with many laterals. Epicotyl purplish, (sometimes sparsely) pubescent. First two leaves opposite, simple, deeply cordate, 4.5–6.5 × 3–4 cm, acuminate at top, sparsely pubescent as is the petiole, green-purplish above, purple beneath. Stipulae deciduous, subulate, ca 1 cm long, glabrescent. Stipellae as a rule present, sometimes absent or only one present.

Notes

1. Usually the stamens are exposed, having left the enclosure of the keel and sometimes the keel tends to change its position in the direction of the exposed, upwards directed stamens.
2. Seedlings and flowers turn black after drying as well as after conservation on spirit. Pods turn black only after conservation on spirit, the liquid becoming dark brown to black.
3. The description is based on four samples only, raised from the same seed sample.
4. Plants raised in the greenhouse at Wageningen under long-day circumstances produced luxurious vegetative growth but did not flower and fruit. Under short-day (11 hours) all plants flowered and fruited.

Taxonomic notes

(1) In Wallich's Numerical List (1828) *Mucuna utilis* Wallich has not been listed. Also in the Wallich Herbarium (Kew) no specimen of the plant is present, but number 5616 of the Wallich Herbarium contains several specimens of *Mucuna pruriens* (L.) DC. from different origins. One of them, 5616-F, bears the annotation that it was cultivated in the Hortus Botanicus Calcuttensis, which is in agreement with the information in Wallich's Numerical List. This specimen (with a many-flowered inflorescence and young velvety fruits) lacks the stinging hairs characteristic for *Mucuna pruriens* var. *pruriens*. It seems not unlikely that this specimen is a cultivated form of *Mucuna pruriens*. It even might have stood for the plant depicted in Wight's Icones, where a specimen is shown with a many-flowered inflorescence, and which is *Mucuna utilis* Wallich. However, no annotation is found on the sheet of specimen no. 5616-F in the Wallich Herb. that confirms the above mentioned suggestion. Besides, the inflorescence of the drawing and the herbarium specimen are not identical, whereas the mature fruits depicted in the Icones are lacking on the herbarium specimen. Under these circumstances it seems preferable to adopt the plate in Wight's Icones (cf. Ic. Pl. Ind. Or. 1: t. 280 (1840)) as the lectotype of *Mucuna pruriens* (L.) DC. cv.-group Utilis.

Cv.-group Utilis lacks the stinging hairs on the pods which are characteristic for var. *pruriens*. In a way cv.-group Utilis can be considered as a cultivated botanical variety. I designate the sample collected in Ethiopia as cv. Velvet Gimbi (based on WP 3385A, WP 8625, WP 8626 and WP 8627).

(2) It might be that a monographer, revising the genus *Mucuna* Adans. on a world-

wide basis, will consider it necessary to divide the genus into two genera, *Mucuna* and *Stizolobium* P. Br. In *Stizolobium* the seeds are compressed oblong–ovoid with a very short hilum surrounded by a conspicuous rim aril, whereas in typical *Mucuna* the seeds are discoid, large and flat with a hilum taking up three quarters of the circumference and without an aril. There are associated characteristics but these have not been studied for more than a few species. The first leaves above the cotyledons are opposite, simple and cordate in *Stizolobium*, whereas in *Mucuna* proper the initial leaves are said to be all alternate and scale-like. The dorsifixed anthers in *Mucuna gigantea* (Willd.) DC. are barbate, whereas in *M. pruriens* (L.) DC., *M. glabrialata* (Hauman) Verdc. and *M. stans* Bak. (all of which belong to *Stizolobium*) they are glabrous. An examination of the pollen of a few species showed that in subgenus *Stizolobium* the walls are thin with an easily visible open reticulation, whereas in *Mucuna* they are thick and the reticulation is much closer and more difficult to see. Despite the marked differences between the two groups, there are also great similarities (e.g. general flower structure, stiffened keel apex, inflorescence structure and presence of irritant hairs). At present it seems justified to follow the general tradition in maintaining a single genus divided into two well-marked subgenera. *M. pruriens* then fits into subgenus *Stizolobium* (P. Br.) Prain.

(3) *Mucuna utilis* has been listed neither by Wallich in his Numerical List of dried specimens of plants (1828), nor is it present in his herbarium. In Wight's Icones Plantarum Indiae Orientalis (1840) a short description is given of the plant depicted in tabula 280: '*Mucuna utilis* (Wall. MSS). The principal difference of this species, if indeed a species, and *M. prurita* consists in the hairs of its legumes, being appressed and almost silky, not erect, rigid and stinging. In all other respects they sufficiently agree. The flowers in both are purple. The greater size of this is probably attributable to cultivation, in which state only it is known'. However, this specimen shows an inflorescence with numerous flowers, whereas the specimens raised in the greenhouse at Wageningen from Ethiopian seeds show no more than 1–3 flowers per inflorescence. In addition, in the Ethiopian specimens the stamens frequently protrude from the keel and stand upright against the standard. This phenomenon is lacking in the drawing in Wight's Icones. Otherwise the drawing is closely in agreement with the described Ethiopian material.

Frahm-Leliveld collected a specimen of *Mucuna deeringiana* (Bort) Merr. (WAG!) in Ivory Coast which shows the stamens protruding from the keel and standing upright against the standard.

Baker, in: Hooker's Flora of British India (vol. 2: p. 187 (1879)) mentions a variety of *Mucuna pruriens* occurring in Ceylon with short usually two-flowered peduncles. It seems that the number of flowers per inflorescence may vary considerably in this species.

(4) Many species of the genus *Mucuna* possess hairs, which, when penetrating the human skin, give rise to considerable irritation. The English name 'cowitch' came into being on account of this, derived from the Hindi name 'kewach'. Well-known is *Mucuna pruriens* described by Rumphius under the name *Cacara prurita* (Herb. Amb.

5: p. 393, t. 142 (1749)) being a wicked plant. Species with few or no stinging hairs are used as vegetables, cover crops and green manure. Among these the first to attract attention was Rumphius's *Cacara nigra* (Herb. Amb. 5: p. 381, t. 138 (1747)). It was rather rare in Amboina but more frequent in Java, Bali, Sumatra and other Malayan islands. Rumphius also described *Cacara pilosa* (Herb. Amb. 5: p. 392 (1747)), planted by the Amboina people in their gardens. Loureiro (Flora Cochinchinensis: p. 461 (1790)) mentioned another cultivated species in Cochin-China, to which he gave the name *Marcanthus cochinchinensis*, with an esculent pod, which, however, was neither tasty nor healthy. Next, Roxburgh detected two species in India (*Carpopogon capitatum* and *C. niveum;* Flora Indica: p. 553-554 (1874)). A third was described by Wallich (*Mucuna utilis*; Wight, Ic. Pl. Ind. Or. 1: t. 280 (1840)). About the same time Von Siebold found one in Japan, there known as 'hassjoomame', and published it under the name *Dolichos hassjoo*, but no description is given (Verhandelingen Bataviaasch Genootschap 12: p. 55 (1830)). In 1842 Hasskarl obtained yet another species in Java, which he named *Mucuna velutina* (Cat. Hort. Bog.: p. 277).

According to Burkill (1966), in the past *Mucuna* was widely cultivated in Asia, but it became obsolete with the introduction of more palatable legumes. Voigt (Hort. Suburb. Calcutt.: p. 235 (1845)) mentions the extensive cultivation of *M. utilis* in Mauritius and Van Diemen's Land as a table vegetable and as a fodder for cattle. This plant is a type with black, shiny seeds commonly known as Mauritius bean ('Pois noir de Bourbon'). At some time *Mucuna* also reached the West Indies and from there it came to Florida at least as early as 1875. There it attracted attention under the name 'Florida velvet bean'. At first, botanists thought it to be identical with Wallich's *Mucuna utilis*, but after a detailed study Bort separated it as *Stizolobium deeringianum* (U.S.D.A. Bur. Plant Ind. Bull. 141: p. 31 (1909)). At that time the Florida velvet bean is nearly always utilized as a fodder crop in pastures.

The demand for cattle-fodder in the U.S.A. stimulated further investigations on the genus, particularly by Piper & Tracy (U.S.D.A. Bur. Plant Ind. Bull. 179 (1910)), resulting in the following useful species.

(a) *Stizolobium deeringianum* Bort (syn. *Mucuna deeringiana* (Bort) Merr.)): Florida velvet bean, Georgia velvet bean.

(b) *S. capitatum* (Wight & Arnott) Kuntze (syn. *M. capitata* Wight & Arnott).

(c) *S. utile* (Wall. ex Wight) Piper & Tracy (syn. *M. utilis* Wall. ex Wight): Bengal bean.

(d) *S. cinereum* Piper & Tracy.

(e) *S. niveum* (Roxb.) Kuntze (syn. *Carpopogon niveum* Roxb., *M. nivea* Wight & Arnott, *M. lyonii* Merr., *M. cochinchinensis* (Lour.) A. Chev.).

(f) *S. hassjoo* (Sieb.) Piper & Tracy.

(g) *S. aterrimum* Piper & Tracy (syn. *M. aterrima* (Piper & Tracy) Merr.): Mauritius bean.

(h) *S. pachylobium* Piper & Tracy.

(i) *S. velutinum* (Hassk.) Piper & Tracy (syn. *M. velutina* Hassk.).

All these finely cut species, mainly distinguished on the nature of the hairs and the

colour of the seeds and the flowers, are so similar that they must be of common origin. Dittmer (Koultournaja Flora SSSR 4: p. 393 and following (1937)) reduces most of the species of Piper & Tracy to subspecies of *S. utile*. Backer (in: Flora of Java 1: p. 629 (1963)) reduces several of the above mentioned species to formae of *M. pruriens*. It seems likely that most of them, if not all, are merely cultivars of *M. pruriens*, as Verdcourt suggests (Flora Trop. East Africa, Leg. 4, Papil. 2: p. 567 (1971)).

(5) The description is based on the following specimens.

Wellega	Gimbi market: WP 3385A.
Grown at Wageningen	WP 7514, WP 7515, WP 8625–WP 8627.

Ecology

Not much is known on the ecology of *Mucuna pruriens*. As only scanty information is available on several of the cultivars listed as separate species, there is enough reason for considerable restrain. Roxburgh (Flora Indica: p. 553–554 (1874)) mentions for two cultivated types *(Carpopogon capitatum* and *C. niveum)* that they are grown as garden crops and flower during the cold season. Wilczek (Flore Congo Belge 6: p. 131 (1954)) describes the habitat of cv.-group Utilis as 'lisières et galeries forestières, savanes, cultures'.[12]

Husbandry

According to Whyte et al. (1953) velvet beans are vigorous annual to perennial vines, but bushy types also exist. They thrive on all soils, even on poor sands and are excellent for soil cover and green manure. They may be used to suppress *Cyperus rotundus* L. and *Imperata cylindrica* (L.) P. Beauv. The vining types have to be planted with maize or other crops for support. In the U.S.A. the Florida or Deering velvet bean *(M. deeringiana)* needs 8–9 months to ripen. It is better suited to colder climates than *M. aterrima*. The Georgia and Alabama cultivars are much earlier. The Yokohama bean *(M. hassjoo)* ripens rather early, but yields less and shatters its seeds. Another promising type for tropical countries is *M. aterrima*. This drought resistant annual establishes quickly and gives a dense cover which smothers weeds. It is useful as green manure and for rotational grazing under coconuts. It may be grown in pure stands or mixed with other legumes or grasses, or it can be planted between rows of maize or sorghum to provide grazing after the cereal is harvested. In Brazil it is grown mixed with high erect grasses which are not smothered by the beans (Whyte et al., 1953).

Information on the cultivation of cv.-group Utilis is not available for Ethiopia nor for other countries.

12. Wooded river banks and gallery forests, savannas, or cultivated fields.

Uses

Young leaves and young pods are eaten as a vegetable, but in Indonesia, according to Ochse (1931), the young pods are not consumed. Mature seeds are eaten but considerable care should be taken in their preparation, as a toxic substance is present in the seed coat as well as in the seeds. Boiling and soaking in repeatedly changed water appear to eliminate this toxic principle. Another preparation of the seeds is fermenting: after boiling the seed coats are removed, the seeds are soaked in running water, chopped, steamed and then left to ferment. In Indonesia mature seeds are roasted and consumed. Young seeds are edible only after boiling and removal of the seed coat; then they are washed in fresh water and steamed. The taste is good and almost that of horse beans. Without such precautions (like boiling, soaking, removal of the seed coat), headache and dizziness follow after consumption (Aykroyd & Doughty, 1964; Heyne, 1927; Terra, 1966).
In many parts of Africa and Asia the seeds are regarded as a famine food; in East Africa it is not popular and is mainly used in times of scarcity (Aykroyd & Doughty, 1964).

More recently the crop is used as cover crop, for pasture, and for fodder, hay, silage and green manure.

Protein content

Ripe seeds: ca 24% (Terra, 1966).

(10) Phaseolus L.

Linnaeus, Gen. Pl. ed. 5: p. 323 (1754); De Candolle, Prodr. 2: p. 390–396 (1825); Bentham, Comm. Leg. Gen.: p. 72–78 (1837), in: Bentham & Hooker, Gen. Pl. 1(2): p. 453 (1865); Taubert, in: Engler & Prantl, Die natürl. Pflanzenfam. 3(3): p. 379–380 (1894); Piper, Contr. U.S. natn. Herb. 22(9): p. 673–701 (1926); Verdcourt, Kew Bull. 24(3): p. 507–526 (1970).

Type of genus: *Phaseolus vulgaris* L.

Description of the genus

Flowers solitary or 2–4-nate on 1–~ tubercles of the rachis of axillary racemes; calyx with or without 2 basal bracteoles; limb of standard with 2 basal auricles; keel adhering to the wings, terminated by a long, obtuse, more or less spiral, no hard beak, which is twisted out of the median of the flower, above the base often unilaterally spurred; vexillar stamen free, above the base often thickened or appendiculate; other stamens connate; anthers uniform; ovary subsessile, 3–~-ovuled; style bearded near the top; stigma obliquely decurrent or placed on the vexillar side; pod linear or sword-shaped, straight or falcate, 2-valved, septate between seeds; hilum short; caruncle (?)

present or absent; albumen none. Stipules long-persistent; leaves pinnately 3-foliolate, stipellate. Herbs or shrubs, twining, erect or decumbent.[13]

Remarks

1. Distribution and uses

Phaseolus L. is a large genus with some 150 to 200 species, mostly annuals or perennials, erect or twining herbs, natives of China, India, and Central and South America, but predominantly American. They are now found throughout the warm regions of both hemispheres. Many of the New World species are perennials. Flowers are white or, more often, pigmented with red to purple anthocyanins. Yellow is less common. Pods of the cultivated species are medium to large, cylindrical or broad. Many of the Old World species have yellow flowers, and all these have morphological features of the flowers that contrast with floral structure of the American beans. Six Asian-African species, including the grams, urds, mung and rice beans, are widely cultivated in Asia. These are annuals, have small cylindrical pods and small seeds. Differential susceptibility to certain fungus diseases further distinguishes the Old and New World species. In the New World four species have been most important as food crops: *P. vulgaris* L., *P. acutifolius* Gray cv.-group Latifolius, *P. lunatus* L. and *P. coccineus* L. (Kaplan, 1965).

Morphological and other features which distinguish the domesticates from the wild taxa are: increase in seed size, increase in permeability of seeds to water intake, reduction in fleshiness of the root system and loss of perennialism, reduction in shattering of pods and violent seed dissemination (Kaplan, 1965). Purseglove (1968) mentions in addition: reduction of parchment layers of pod, and in the amount of the glucoside phaseolunatin in seeds which, after dehydrolysing by enzyme action, produces hydrocyanic acid.

The close relationship between beans and maize in the indigenous diet of the populous cultures of Central America and the Andean region is not accidental. Quantitative chemical analyses of maize and beans of contemporary Yucatan Indians have shown complementation in the amino acids of zein, the principal maize protein, and a and b globulins of the black beans *(P. vulgaris)*, that form the staple of the diet together with maize. Beans are rich in the amino acids lycine and tryptophane and these complement the amino acids of zein of maize, so that food with a protein content of a high biological value is achieved (Kaplan, 1965).

The routes by which beans have been brought to Africa are various and their introduction may be assigned partly to the Portuguese but the possibility exists of earlier introductions from the Far East into East Africa and, in recent years, a large number of cultivars have been introduced from Europe and North America (Stanton et al., 1966).

13. Adopted from Backer & Bakhuizen van den Brink, Flora of Java 1 (1963).

Pulses of *Phaseolus* species belong to the most important sources of protein in the diet of many tropical people and supplement the carbohydrate staple foods of rice, maize and other cereals. In addition to this, dried pulses, immature pods and seeds of most of the beans are eaten as vegetables.

The most important and most widely cultivated species are *Phaseolus vulgaris* L. (kidney bean) and *P. lunatus* L. (lima bean). In India, *P. radiatus* L. (green gram) and *P. mungo* L. (black gram) are important pulse crops. *P. aconitifolius* Jacq. (mat or moth bean), *P. acutifolius* Gray cv.-group Latifolius (tepary bean), *P. angularis* (Willd.) W. F. Wight (adzuki bean) and *P. calcaratus* Roxb. (rice bean) are pulse crops of minor importance. *P. coccineus* L. (scarlet runner bean) is an important summer vegetable in Europe, but can be grown only at higher altitudes in the tropics. A number of species are grown as green manure and cover crops and also for fodder. These include *P. aconitifolius*, *P. radiatus*, *P. calcaratus*, *P. lathyroides* L., *P. lunatus*, *P. mungo*, and others.

2. The Phaseolus/Vigna complex

The distinction between *Phaseolus* L. and *Vigna* Savi is one of the major problems in the classification of the tribus *Phaseoleae*. In the past, differentiation between the two genera was based on the degree to which the beak of the keel was incurved.

Linnaeus (Sp. Pl. ed. 1: p. 723 (1753)) included 11 species in *Phaseolus*, namely (1) *P. vulgaris*, (2) *coccineus*, (3) *lunatus*, (4) *inamoenus*, (5) *farinosus*, (6) *vexillatus*, (7) *helvulus*, (8) *alatus*, (9) *caracalla*, (10) *radiatus* and (11) *max*. In current literature these are respectively equivalent to (1) *P. vulgaris*, (2) *P. coccineus*, (3) *P. lunatus*, (4) identity uncertain, (5) probably a 'mung'-like plant, (6) *Vigna vexillata* (L.) A. Rich., (7) *Strophostyles helvula* (L.) Elliott, (8) identity uncertain, (9) *P. caracalla*, (10) *Vigna radiata* (L.) Wilzcek and (11) *Glycine max* (L.) Merrill. In Gen. Pl. ed. 5: p. 323 (1754) Linnaeus gives the following important characteristic: 'carina ... spiraliter contra solem revoluta ... Obs. Carina cum contortis genitalibus spiralis, essentialis est nota'.

De Candolle (Prodr. 2: p. 390-396 (1825)) divides the genus into the sections *Euphaseolus* and *Strophostyles* (Elliott) with five subgroupings in the first and two in the second.

Savi (Nuovo G. Lett. Pisa 3: p. 308 (1822)) gives for *Phaseolus* L. the following characteristic: 'carina spiraliter convoluta, vel falcata, vel uncinata'. Within the *Dolichos* complex he distinguishes the genera *Soja*, *Lablab*, *Dolichos*, *Malocchia* (all characterized by 'calycis labium superius emarginatum, vel bidentatum') and *Vigna* ('calycis labium superius integrum') (Nuovo G. Lett. Pisa 8: p. 112-113 (1824)). The latter genus is described by Savi as follows: 'calli ad basim vexilli, superne convergentes; nectarium thecaphorum cingens; legumen teres incurvum; semina ecaruncula-ta, umbilico ventrali' (l.c. p. 113).

Bentham (Comm. Leg. Gen.: p. 72-78 (1837)) gave a synopsis of the genus *Phaseolus* mentioning 85 species distributed in 7 sections: *Drepanospron*, *Euphaseolus* DC.,

Leptospron, *Strophostyles* (Elliott) DC., *Lasiospron*, *Microcochle* and *Macroptilium*. Later (in: Bentham & Hooker, Gen. Pl. 1(2): p. 453 (1865)) he excludes *Lasiospron* and *Microcochle* but adds *Dysolobium*. Here he states: '*Phaseolus* – carina spiralis; ... *Vigna* – carina obtusa v. arcuata–rostrata; omnia Phaseoli nisi carina erostris v. rostro obliquo valde incurvo sed spiram perfectam non efficiente'. *Dysolobium* and *Macroptilium* have since been recognized as distinct genera by Prain (J. Ass. Soc. Beng. 66: p. 425 (1897)) and Urban (Symb. Antill. 9: p. 457 (1928)) respectively. It was gradually realized that this distinction between the two genera, as mentioned by Bentham, is not satisfactory and that certain Old World species placed by this criterion in *Phaseolus* are probably more closely related to species of *Vigna* than they are to the New World species of *Phaseolus* (which include the type species *P. vulgaris* L.).

A. Richard (Tent. Fl. Abys. 1: p. 216 (1847)) suggested that *Dolichos*, *Vigna* and *Phaseolus* might constitute three sections of one single, natural genus. The enrolled keel by itself, however, is a characteristic which appears in several genera in the tribus *Phaseoleae* and is not correlated in such a way as to suggest that they are a natural group. When the keel is strongly incurved the free part of the filaments and the basal part of the style are both elongated and tenuous; consequently these three characteristics must be considered as an entity (Verdcourt, Kew Bull. 24(3): p. 510 (1970)).

At least one botanist has 'solved' the problem by uniting *Vigna* and *Phaseolus:* Gagnepain, in: Lecomte, Fl. Gén. l'Indo-Chine 2: p. 224 (1916), although he did not do this to solve the specific problem.

Hassler (Candollea 1: p. 417-427 (1923)) reviewed the South American species and maintained five sections: *Euphaseolus* DC., *Drepanospron* Benth., *Leptospron* Benth., *Macroptilium* Benth. emend., and *Strophostyles* (Elliott) DC., and described a number of series in each.

Piper (Contr. U.S. natn. Herb. 22: p. 663-701 (1926)) published an account on the American species of *Phaseolus* and its allies based on a profound knowledge of the group. He recognized eight sections: *Sigmoidotropis*, *Ceratotropis*, *Lasiospron* Benth., *Macroptilium* Benth., *Microcochle* Benth., *Cochliasanthus* (Trew.), *Leptospron* Benth. and *Euphaseolus* DC.

By and large, however, the genus *Phaseolus* retained much of the defined description until Ohwi, in his Flora of Japan, established *Azukia* for the 'mung' group. Morphologically and geographically this group can be separated from *Phaseolus vulgaris* and its allies, as has been noticed before Piper created the section *Ceratotropis*. Ohwi (Flora of Japan: p. 690-691 (1953); English ed. of Meyer & Walker: p. 567-568 (1965)) separates five Japanese species of *Phaseolus*, including *P. angularis*, *calcaratus*, *radiatus* and *aureus*, which would have been included in section *Strophostyles* (Elliott) DC. by Bentham, to form this new genus *Azukia* (type species *A. angularis* (Willd.) Ohwi)). Since Ohwi did not deal with non-Japanese plants it is unknown how many of the last he might have considered to belong to *Azukia*. However, Ohwi & Ohashi (J. Jap. Bot. 44: p. 29 (1969)) have agreed later on that *Azukia* should be merged with *Vigna*.

Wilzcek (Fl. Congo Belge 6: p. 261 (1954)) keys out the two genera as follows

Phaseolus: stipules not prolonged below the point of insertion; keel in a spiral of 1–5 complete turns; stigma elongated, internal or sometimes very short and terminal or subterminal; style without an apical appendage.
Vigna: stipules prolonged below the point of insertion; keel erect–incurved, rarely making almost 1 complete spiral turn; style ending beyond the stigma in a more or less distinct beak.

On this base Wilczek transferred, for instance, *P. radiatus* to *Vigna*, and retained *P. schimperi* Taub., which has often been placed in *Vigna*, in *Phaseolus*.

Hepper (Fl. Trop. W. Africa ed. 2, 1: p. 508 (1958)) makes the following distinction

Phaseolus: stipules truncate at the base; keel spirally twisted; fruit not septate.
Vigna: stipules cordate or appendaged below the base; keel straight or spirally twisted; fruit septate.

Tourneur (Riz Rizic. 4: p. 131-148 (1958)), studying the seeds and seedlings of some *Phaseolus* and *Vigna* species, considers that in *Vigna* the first pair of leaves after the cotyledons is sessile, while in *Phaseolus* it is petiolate. He comes to the conclusion that the transfer of *P. radiatus* and *P. mungo* by Wilzcek and Hepper, respectively, is correct. Unfortunately, besides *P. radiatus* and *P. mungo*, he only studied *P. lunatus*, *P. vulgaris*, *V. unguiculata* (L.) Walp. and two other *Vigna* spp. Generalizations based on so small a sample of the total number of species are not reliable.

Despite the numerous attempts to redefine the distinction between *Phaseolus* and *Vigna*, no clear solution to the problem has been reached up till now. Several efforts have been made to reduce the confusion by subdividing either *Phaseolus* or *Vigna*, or both. However, all such attempts were based on the study of only relatively few of the total number of species, and no sound decisions can be reached until all the species of the subtribe have been examined. Studies in pollen morphology may supply some additional information, results of biochemical studies may support various changes suggested on morphological grounds, but in other cases they provide no evidence or do not fit with other data. Insufficient knowledge is available on germination habits, but both epigeal and hypogeal germination are found in the same taxon. Cytological data will not help much in solving the problem, as Frahm-Leliveld (Euphytica 14: p. 251-270 (1965)) has shown that in *Vigna* species with the basic diploid number of usually 22, deviations of 20, 21, 23, 24 and rarely 44 occur.

Since, according to Verdcourt (Kew Bull. 24(3): p. 509-510 (1970); Flora Trop. East Africa, Leg. 4, Papil. 2: p. 618 (1971)), the type species (*Phaseolus vulgaris* L., *Vigna luteola* (Jacq.) Benth.)) are clearly centrally placed examples of natural groupings, and since 'typical' *Phaseolus* and 'typical' *Vigna* are clearly distinct, the merging of the two genera into one is no solution. Alternatively, the subdivision of the combined pair into a series of smaller genera would be premature and involves creating a large number of new genera.

The best solution may be to separate off difficult marginal groups as genera or subgenera. Consequently Verdcourt (1970) proposes to restrict *Phaseolus* to those species which closely resemble *P. vulgaris*, *P. lunatus* and *P. coccineus* in having no prolonged stipules, keel and thickened part of style twisted through more than 360°, keel without a 'pocket', and having pollen grains with a fine (not coarsely reticulate) sculpture. Other groups previously retained in *Phaseolus* may be separated (e.g.

Macroptilium (Benth.) Urb., *Strophostyles* Elliott) or moved to *Vigna* which is divided into a number of subgenera and sections pending further study. In this way scarcely 50 species remain in *Phaseolus*.

3. Revision of the genera Phaseolus and Vigna

No extensive treatment of the genus *Phaseolus* is more recent than of Bentham. Since then many isolated species have been proposed, and in various floras of limited areas only the native species have been considered. Nearly all the species of *Phaseolus* show great variation in the shape of the leaflets. Such variants are scarcely important as to taxonomic recognition. Many species and subspecies have been based on leaflet shape or on slight differences in pubescence, characteristics which in *Phaseolus* are decidedly untrustworthy. The relations of the different groups in the genus are not very clear (Piper, 1926). Smartt (in: Ucko & Dimbleby, eds, 1969) goes so far that he judges the present taxonomic treatments of the genus *Phaseolus* not only unhelpful but decidedly misleading. De Candolle, Taubert and Piper all placed some closely related species in different sections of the genus. The quality of much of the herbarium material available is very poor, very often without flowers and in many cases inadequate for a reliable determination. A modern taxonomic revision of this important genus, Smartt concludes, is long overdue.

Clearly the confusion between the genera *Vigna* and *Phaseolus*, which contain such important economic species, is intolerable. A revision of both genera on a world-wide basis is necessary.

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(10A) Phaseolus coccineus L. Fig. 14; Plate 16

'*Phaseolus*': Lat. transcription from Greek 'phaseolos', meaning: a bean; also translated as a small boat, because of the shape of the pods (Alefeld, 1866: p. 2).
'*coccineus*': derived from Lat. 'coccum', a kind of louse, resembling a red berry, and so being (red) coloured like the pigment produced by that insect.

Linnaeus, Sp. Pl. ed. 1: p. 724 (1753).
Type: a plant cultivated at Uppsala; '*Phaseolus* caule volubili, ..., bracteis brevioribus, leguminibus pendulis' (LINN, specimen 899.2, lecto.!).

Synonyms

Phaseolus vulgaris var. *coccineus* L., Sp. Pl. ed. 2: p. 1016 (1763).
Phaseolus multiflorus Lam., Encycl. 3: p. 70 (1789); Willd. Sp. Pl. ed. 4, 3: p. 1030 (1803).
Phaseolus multiflorus var. *albiflorus* Lam., Encycl. 3: p. 70 (1789).
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Phaseolus multiflorus f. *bicolor* (Arrab.) Beck, l.c.

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Local names: ?
Trade names: scarlet runner (bean), runner bean, Dutch case-knife bean (white cv.) (English); haricot d'Espagne (French); judia escarlata (Spanish).

Geographic distribution

Indigenous runner bean cultivation is most advanced in the cool humid uplands of Chiapas and Guatemala of Central America at altitudes of about 1800 m. In these areas the cultivars and their abundant wild relatives are perennials. It is cultivated to

a more limited extent on the central Plateau of northern Mexico and in Costa Rica, Panama and Columbia. Beans dated 7000–5000 B.C. found in Mexico were probably from wild plants, whereas those at Tehuacan are domesticates and were probably imported from the humid uplands. The limited distribution of archaeological runner beans may only reflect limited excavation in areas where cultivation may be likely. Although this species is cultivated by indigenous people from Hopi country in Arizona down to Columbia, it is restricted to higher elevations and seldom approaches *Phaseolus vulgaris* in importance: perhaps the major niches for vining bean cultivation were already occupied by this highly variable species at the moment runner beans became available. *P. coccineus* is widely distributed in temperate countries, and is also found in the higher regions of Africa and Asia. It seldom occurs in the tropics outside Central America, although it is occasionally grown by Europeans at higher altitudes (Kaplan, 1965; Purseglove, 1968).

In Ethiopia it is sometimes found as a garden crop in the south-west (Kefa, Sidamo and probably also in other provinces of this region). Only a few times seeds were found on markets of the Jima region.

Description

A climbing and branching, slightly pubescent perennial (possibly also grown as an annual in Ethiopia), with thickened tuberous roots (not seen on specimens collected in Ethiopia).

Stems ± terete, slightly ribbed, more or less twisting, often hollow, green, sometimes purplish, thinly pubescent, young stems pubescent; hairs long and short, white or brown.

Stipulae small, triangular, acute to obtuse at top, with numerous, slender, parallelous length-nerves, glabrescent; edge lighter coloured, membranous; top sometimes purple.

Leaves alternate, 3-foliolate. Petiole (6.0–)8.5–10.5(–16.0) cm long, slender, grooved above, glabrescent. Rachis (1.5–)2.5–4.0(–5.0) cm long, grooved above, glabrescent, topped by a leaflet.

Leaflets: First two leaflets opposite and asymmetrical, top leaflet symmetrical, shortly-petioluled (ca 5 mm long) with indumentum distinctly denser than on petiole, (sometimes broadly) ovate–rhombic, (5.0–)6.5–10.5(–12.5) × (3.5–)5.0–8.5(–12.5) cm, entire, cuneate or truncate at base, acuminate and sometimes mucronate at top, palmately 3-nerved and green and thinly pubescent to glabrescent above, grey-green with prominent venation below.

Stipellae prominent, ca 5 mm long, glabrous or nearly so, with venation resembling stipular veines, 1 per lateral leaflet, narrowly triangular–ovate, sometimes purplish, 2 per top leaflet, subulate, sometimes falcate, smaller than the other stipellae.

Inflorescence an axillary raceme with many flowers. Peduncle (5.0–)11.0–16.5(–25.5) cm long, hollow, twisted, ribbed, pubescent when young, gradually glabrescent, with indumentum with long and short, white (sometimes brownish) hairs. Rachis as

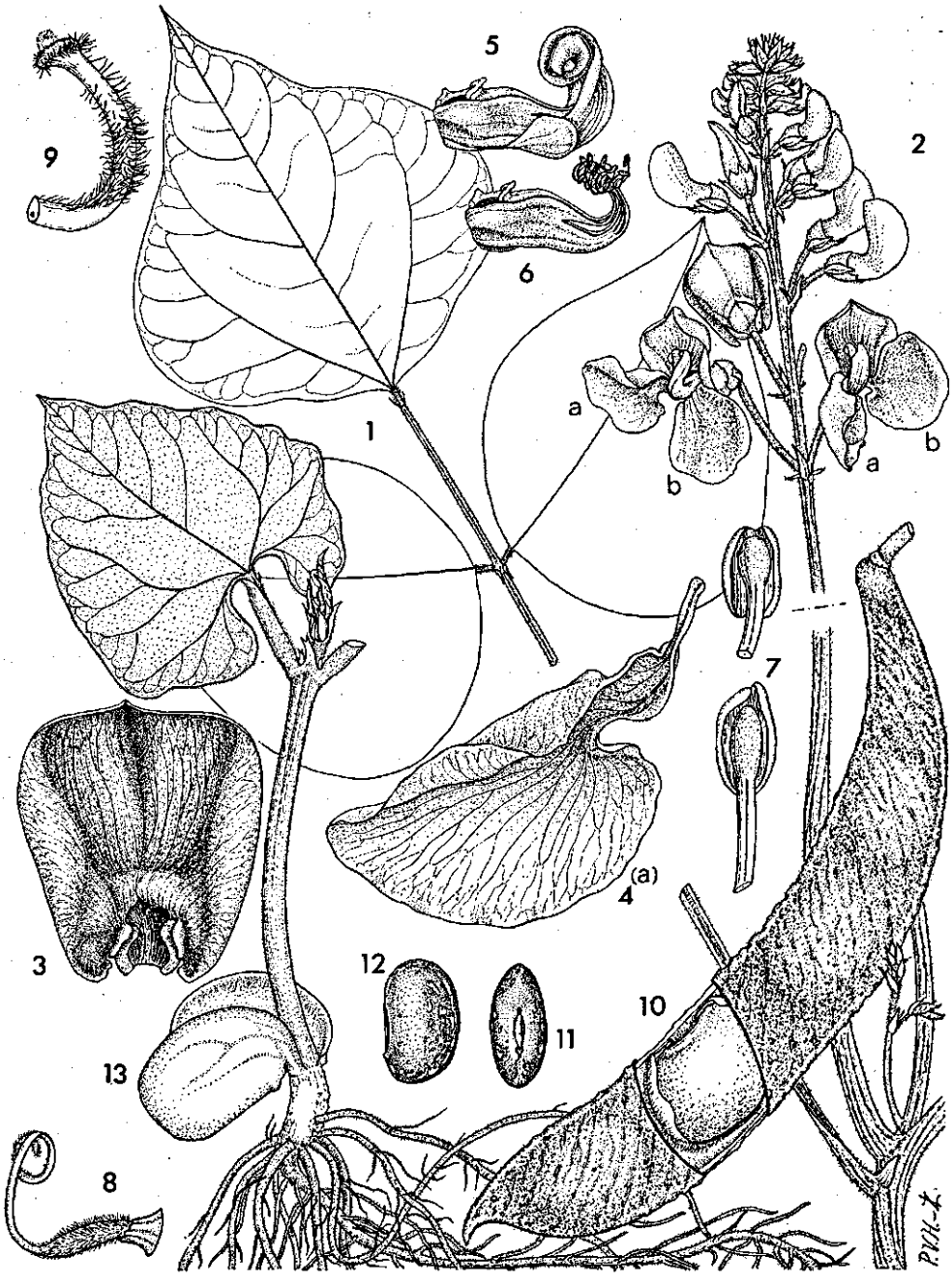

Fig. 14. *Phaseolus coccineus* L. cv. Jima Giant. – 1. leaf (ca ½×); 2. branch with inflorescence (⅚×); 3. standard, adaxial view (2½×); 4. wing (a), adaxial view (2½×); 5. keel + staminal sheath (2½×); 6. staminal sheath (2½×); 7. anthers (15×); 8. pistil + disk (2½×); 9. style + stigma (7½×); 10. pod (⅚×); 11. seed, with hilum (⅚×); 12. seed, lateral view (⅚×); 13. seedling (⅚×). – 1. WP 7896; 2. WP 7898; 3–9. WP 7896 (spirit mat.); 10. WP 7898 (spirit mat.); 11–12. WP 7898; 13. WP 7895 (spirit mat.).

peduncle, but (densely) pubescent, not tuberculate, (2.0–)10.0–16.0(–39.5) cm; flowers arising single or paired; bracts 1 per flower, small, subulate, glabrescent; each group of flowers subtended by a larger bract, narrowly ovate to -triangular, ca (2–)4 mm long, acuminate at top, sparsely pubescent; pedicels laterally compressed, sometimes twisted, (0.5–)1.0(–1.5) cm long, pubescent, gradually glabrescent, with two prominent bracteoles attached at the base of the calyx. Bracteoles (sometimes narrowly) ovate to -elliptic, ca 6 mm long, glabrescent, sometimes purplish and with dark venation.

Calyx campanulate, glabrescent; tube ca 3 mm long; lobes 5, the upper pair of lobes connate forming an entire or slightly emarginate lip, the other three lobes subequal, triangular, ca 1 mm long, acute or acuminate at top.

Corolla: Standard with lower part (claw) directed forward, upper part (limb) erect above a deep sinus, hood-shaped, circular or very broadly obovate, (16–)17(–18) × (16–)17(–19) mm, with longitudinal edges sometimes reflexed, with claw channel-shaped with left and right two callosities (one large, one smaller), bi-auriculate, with auricles sometimes inflexed, emarginate at top, glabrous except for some abaxial hairiness at the top, orange-red. Wings broadly obovate, (23–)25(–28) × (15–)17(–19) mm, clawed, channel-shaped above the claw and upper part slightly fleshier, with only one wing with a 'pocket', rounded at top, papillulate, orange-red, adherent to the keel. Keel sharply upturned, spirally incurved, ca 10 mm long, clawed, split dorsally but connate at the top, ventrally split near the base, 'pocketed', with 'pockets' adherent to the wings, with the apex beaked and forming a spiral of less than two turns, glabrous, white, at top orange-red.

Androecium: Stamens diadelphous (9 + 1). Vexillary stamen free, ca 13 mm long, much shorter than the other stamens, compressed dorsally, tapering towards the top, appendiculate near the base, with appendix fitting between the callosities in the channeled claw of the standard, with upper part upturned and spiralled. Staminal sheath slightly winged, ca 6 mm long when on either side the first filament is released; generally this is (irregularly) followed by two single stamens, while three stamens, including the top stamen, are finally released together, with free part of filaments winged towards the base, and otherwise filiform, and also upturned and spiralled. Anthers ellipsoid, ca 1 mm long, basi–dorsifixed, pale yellow.

Disk collar-shaped, ca 1–2 mm long, oblique, ribbed, often split dorsally, repandous.

Gynoecium: Ovary sessile or nearly so, ca 6 mm long, finely pubescent, with a brown line along the ventral and dorsal margin (material in spirit), beaked, ca 5-ovulate. Style upturned and spiralled, lower part flexible, apical part cartilaginous, hairy below the stigma. Stigma ellipsoid, directed adaxially, surrounded by fine ciliae, glandular, orange-yellow; with an ? excretion on top.

Pod more or less crescent-shaped, laterally compressed, slightly bulging over the seeds, (4.5–)9.0–13.0(–16.0) × (1.5–)1.8(–2.5) cm, beaked, with pod wall rough with small oblique ridges and slightly tuberculate, glabrescent, brown, (1–)3(–5)-seeded; seeds separated by various amounts of intermediate (sept-like) tissue.

Seeds variable in shape, ellipsoid–oblong, laterally compressed, (16–)18–22(–24) ×

(11–)13–(15) mm, shiny black with purple mosaic. Hilum large, oblong, (4.5–)5.5(–7.0) mm long, ± central, covered by a layer of white detachable tissue, brownish, with a prominent twin-bump situated at the opposite side of the hilum where the micropyle is situated. Cotyledons pale yellow.

Seedling with hypogeal germination. Root system strongly developed with many laterals and several adventitious roots. Epicotyl slightly pubescent, green, sometimes purple. First two leaves opposite, simple, deeply cordate, (3–)4–6 × (2–)3.5–5 cm, acuminate at top. Stipulae of the two leaves partly connate. Petiole grooved above, slightly pubescent, as are the veins and edges of the leaves. Stipellae present, subulate, two per leaf.

Taxonomic notes

(1) In Sp. Pl. ed. 1 Linnaeus established *Phaseolus vulgaris* and *P. coccineus* as separate species, but in Sp. Pl. ed. 2 (1963) he considered *P. coccineus* as a variety of *P. vulgaris*.

According to Savage's Catalogue (l.c. p. 126) no specimen of *P. coccineus* in LINN is present. However, the sheet carrying *P. vulgaris* (899.1) is pinned to the following sheet (899.2) which shows in Linnaeus's handwriting the reference by number 2 to Sp. Pl. ed. 1 and H.U. (Hortus Upsaliensis) as well. This second species of *Phaseolus* is in fact *P. coccineus:* the red colour of the flowers is still clearly visible on this specimen in LINN. In fact, Linnaeus, after publishing his first edition in which he considered the two taxa as being different species, changed his concept in the second edition of Sp. Pl., and he pinned the two sheets together.

The specimen in LINN (899.2) is the lectotype of *Phaseolus coccineus* L.

(2) I designate the specimens of the scarlet runner bean collected in Ethiopia as cv. Jima Giant (based on WP 5515, WP 7815, WP 7896 and WP 7898).

(3) The following differences were found between plants raised at Wageningen and in Ethiopia.

	Wageningen	Ethiopia
leaflet: length	5.0–12.5 cm	5.5–10.5 cm
width	3.5–12.5 cm	4.0– 8.5 cm
petiole	8.0–16.0 cm	6.0–11.0 cm
peduncle	5.0–25.5 cm	11.0–14.5 cm
rachis	4.0–39.5 cm	2.0–29.5 cm

(4) The description is based on the following specimens.

Kefa	5 km past Jima on Serbo road, in garden: WP 5493; Agaro market: WP 5515; 52 km past Jima on Bonga road, in garden: WP 5524, WP 5525.
Sidamo	42 km past Dila on Yirga Chaffe road, in garden: WP 4067.
Grown at Wageningen	WP 7895–WP 7900.

Ecology

The scarlet runner bean likely is a quantitative short-day plant that thrives well in the humid uplands of the tropics. It is less sensitive to cool 'summers' than most *Phaseolus* species. It is killed by night frost and consequently in temperate countries it is grown as an annual. In the tropical lowlands it does not set fruit (Purseglove, 1968). It requires a rich deep soil. Little information is available on its growth during the rainy season. According to Stanton et al. (1966) it is a well-known garden crop in the highland areas of Africa, where it appears to include long-day as well as day-neutral and short-day types. This, however, is most unlikely; meant is here that *P. coccineus* exhibits short-day as well as day-neutral types.

In Ethiopia it is found in the south-west below ± 2000 m, in regions with high rainfall (over 1500 mm annually).

Husbandry

In Central America sprouts from the tuberous roots often occupy former maize fields for one or two years during the fallow period. In some fields and in plots near houses the strongly vining runner beans are interplanted with maize. In the home gardens they are treated as perennials with a life span of two to several years. In the temperate countries they are grown as annuals and are given long supports (Purseglove, 1968).

In Ethiopia it is a garden crop growing along supports. It is an annual or perennial.

Uses

Phaseolus coccineus is an annual or perennial vine with climbing or dwarf cultivars. It is cultivated for its tender pods which, in the temperate countries, are usually sliced and cooked. In Central America the green and dry seeds and the fleshy tubers are eaten; the latter are boiled. Except for the highlands of Central America, the dry mature seeds are not of much importance as food (Aykroyd & Doughty, 1964; Purseglove, 1968). Occasionally it is grown as an ornamental. Burkill (1966) suggests that the vegetative parts may be used as fodder but are rarely used in this way.

In Ethiopia the seeds are eaten.

Protein content

Young beans: ca 7.5% (Terra, 1966).

(10B) Phaseolus lunatus L. **Figs. 15, 16; Plates 17–24**

'*Phaseolus*': see *Phaseolus coccineus*.
'*lunatus*': from Lat. luna = moon, the half moon; shaped like a crescent moon.

Linnaeus, Sp. Pl. ed. 1: p. 724 (1753).

Type: habitat in Bengal; '*Phaseolus* caule volubili, leguminibus acinaciformibus sublunatus laevibus'.
Neotype: Westphal 8622 (WAG, holo.; iso.: K, P).

Synonyms
Phaseolus bipunctatus Jacq., Hort. Vindob. 1: p. 44, t. 100 (1770).
For more synonyms see Van Eseltine (1931).

Literature

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1971: Verdcourt, in: Fl. Trop. East Africa, Leg. 4, Papil. 2: p. 615. (tax.)

Local names: fasoelea makke (?); atera bakena (Amarinia); lodjo (Wollamo Gallinia).
Trade names: lima bean (large-seeded cvs), sieva bean (small-seeded cvs), butter bean, Madagascar bean, Rangoon bean, Burma bean (English); haricot de lima, haricot de sieva, pois (haricot) du Cap, haricot Kissi (French); judia de Lima, judia de sieva (Spanish).

Geographic distribution

This native of tropical America is cultivated throughout the warmer parts of the world. It is now the main pulse crop in the wet forest regions of tropical Africa, and is widely grown in Burma. Lima beans have escaped from cultivation and maintain

themselves in a wild state in many tropical countries. The plant is known in a number of different cultivars, all fairly common throughout the tropics. The bush lima cultivars commonly grown in the U.S.A. are not normally found in Africa. For the export trade from Madagascar the large white-seeded climbing forms have been used, but in other parts of Africa the small-seeded climbing types are more common (Cobley, 1963; Purseglove, 1968; Stanton et al., 1966).

Mackie (1943) suggests that the species originated in the Guatemala region of Central America, where wild endemic forms occur. Distribution from there took three directions along the Indian trade routes in pre-Columbian times

(1) the Hopi or northern branch, extending north in the southern U.S.A. areas (small limas);

(2) the Carib or West Indian branch, brought to the West Indies and the Amazon basin (tropical, short-day perennial cultivars of which the beans have the highest content of hydrocyanic acid);

(3) the Inca or southern branch, from Central America to Peru (large, white limas) (Mackie, 1943).

Archæological findings, however, suggest a separate domestication in Central and South America from conspecific geographic races. The large lima bean is present in pre-agricultural times (more than ca 5200 years ago) and continues into later times on the north coast of Peru. It is unknown from the archaeology of Central America. The sieva is absent from Peruvian sites, and its earliest record in Mexico is from 1400–1800 years ago. Mexican sievas and Peruvian large limas are separated throughout archaeological records (Kaplan, 1965). Kaplan assumes that the large lima of Peru may have first been domesticated east of the Andean highlands in warm humid lands and that the sieva of Mexico may have arisen in the Pacific coastal foothills of Mexico.

In post-Columbian times lima beans widely spread, particularly in the tropics. Carib-type beans were taken by the Spanish galleons across the Pacific to the Philippines and from there to Asia. The slave trade took them from Brazil to Africa. All modern large lima beans trace back to Peru and were taken at an early date to Madagascar (Purseglove, 1968).

In Ethiopia the lima bean is especially found in the south-western part of the country, but it is also cultivated in Hararge.

Description

A climbing, slightly white or brownish pubescent perennial (bush forms not seen in Ethiopia).

Stems ± terete, sometimes slightly ribbed, ± twisting, older stems often hollow, and glabrescent.

Stipulae small, triangular, acuminate–acute, with prominent venation, slightly pubescent.

Leaves alternate, 3-foliate. Petiole (5.0–)8.0–13.5(–19.0) cm long, grooved above, (slightly) pubescent, with dark green pulvinus. Rachis (1.5–)2.0–4.0(–8.0) cm long,

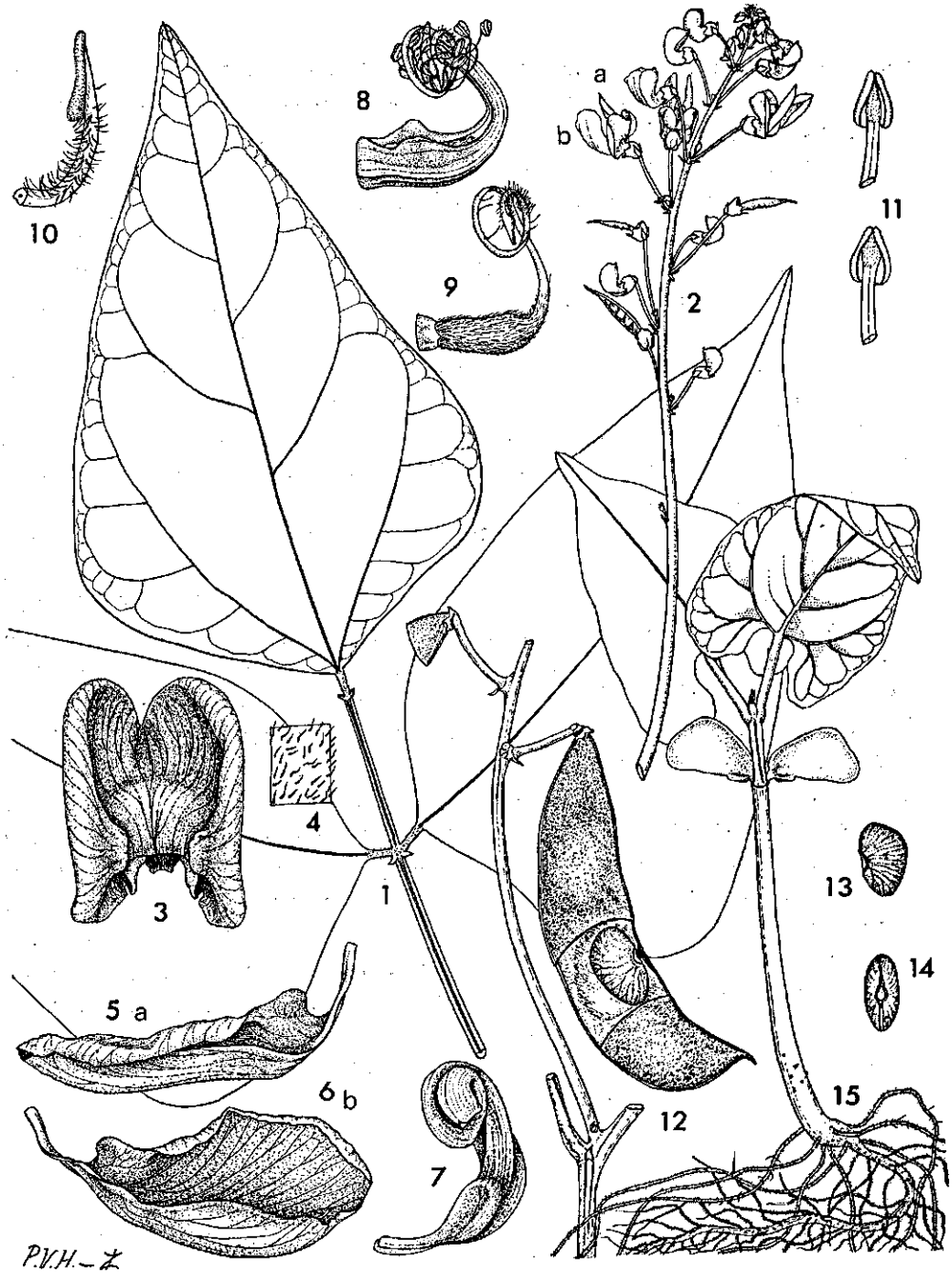

Fig. 15. *Phaseolus lunatus* L. cv. Maji Moon. – 1. leaf (5/6×); 2. inflorescence (5/6×); 3. standard, adaxial view (5×); 4. standard, detail of abaxial pubescence (10×); 5. wing (a), adaxial view (5×); 6. wing (b), adaxial view (5×); 7. keel (5×); 8. staminal sheath + pistil (5×); 9. pistil + disk (5×); 10. top part style + stigma (15×); 11. anthers (15×); 12. branchlet with pod (5/6×); 13. seed, lateral view (5/6×); 14. seed, with hilum (5/6×); 15. seedling (5/6×). – 1. WP 8649; 2. WP 8648 (including spirit mat.); 3–11. WP 8648 (spirit mat.); 12. WP 8649 (including spirit mat.); 13–14. WP 8569A; 15. WP 8647 (spirit mat.).

grooved above, (sometimes slightly) pubescent, topped by a leaflet.

Leaflets: First two leaflets opposite and (conspicuously) asymmetrical, top leaflet symmetrical, shortly petioluled (ca 5 mm long) with indumentum denser than on petiole, ovate, top leaflet sometimes shallowly lobed at base or broadly triangular, (5.5–)7.0–13.0(–19.5) × (3.0–)4.5–8.5(–11.0) cm, entire, truncate or cuneate at base, acuminate and mucronulate at top, palmately 3-nerved, green, (slightly) pubescent to nearly glabrous, with lower surface grey-green and venation more prominent.

Stipellae small, linear, glabrous or nearly so, at the base of the petiolule, 1 per lateral leaflet, 2 per top leaflet.

Inflorescence a supra-axillary, delicately branching, narrow raceme with several flowers. Peduncle (0.5–)2.0–7.5(–12.5) cm long, slightly twisted and ribbed, flattening towards the base, (slightly) pubescent to glabrescent. Rachis (0–)2.0–8.0(–18.0) cm long, slightly ribbed, (slightly) pubescent to glabrescent, not tuberculate; flowers arising 1–4 together; bracts 1 per flower, persistent, linear, small, ca 1 mm long, slightly pubescent; each group of flowers subtended by a larger bract, persistent, narrowly triangular, ca 2 mm long, acuminate at top, with lighter coloured venation, slightly pubescent; pedicels up to ca 10 mm, slender, slightly pubescent, with two small bracteoles attached at the base of the calyx. Bracteoles persistent, ca 1.5 mm long, ovate to elliptic, with lighter coloured venation, slightly pubescent.

Calyx campanulate, pubescent; tube gibbous dorsally, ca 1–2 mm long; lobes 5, the upper pair of lobes connate forming an emarginate lip, the other three lobes subequal, broadly triangular, ca 1–2 mm long, acute at top.

Corolla: Standard with lower part (claw) directed forward, upper part (limb) erect above a deep sinus, hood-shaped, forming an enclosure for the upturned top of the keel, very broadly obovate, (7–)10(–12) × (7.5–)11(–12) mm, with longitudinal edges reflexed, with concave claw, bi-auriculate, with prominent, fleshy and inflexed auricles, emarginate at top, finely pubescent abaxially, yellow-green. Wings ladle-shaped, (10–)12(–16) × (4.5–)6(–8) mm, projecting forward, clawed, auriculate (finely transversely striate near the auricle), rounded at top, glabrous, white (turning yellow-orange), adherent to the 'pockets' of the keel. Keel sharply upturned, ca 5–7 mm long, clawed, weakly auriculate, dorsally and ventrally split near the base, with left and right a 'pocket', with the apex spiralled (forming less than 2 turns), not connate at top, hiding the stigma, glabrous, yellow-green.

Androecium: Stamens diadelphous (9 + 1). Vexillary stamen free, ca 10 mm long, compressed dorsally, tapering towards the top, with a swollen base, with upper part curving and spiralled. Staminal sheath slightly winged, upturned, ca 6 mm long when on either side the first filament is released, irregularly followed by the other 7 stamens, with free part of filaments winged at base, spiralled. Anthers ellipsoid, less than 1 mm long, alternately basi- and dorsifixed, yellow.

Disk collar-shaped, ca 1 mm long, ribbed, sometimes split dorsally.

Gynoecium: Ovary sessile, laterally compressed, ca 4 mm long, finely velvety, beaked, ca 2-ovulate. Style upturned and spiralled, at base finely pubescent, with lower part flexible and apical part cartilaginous, sometimes beaked beyond the stigma,

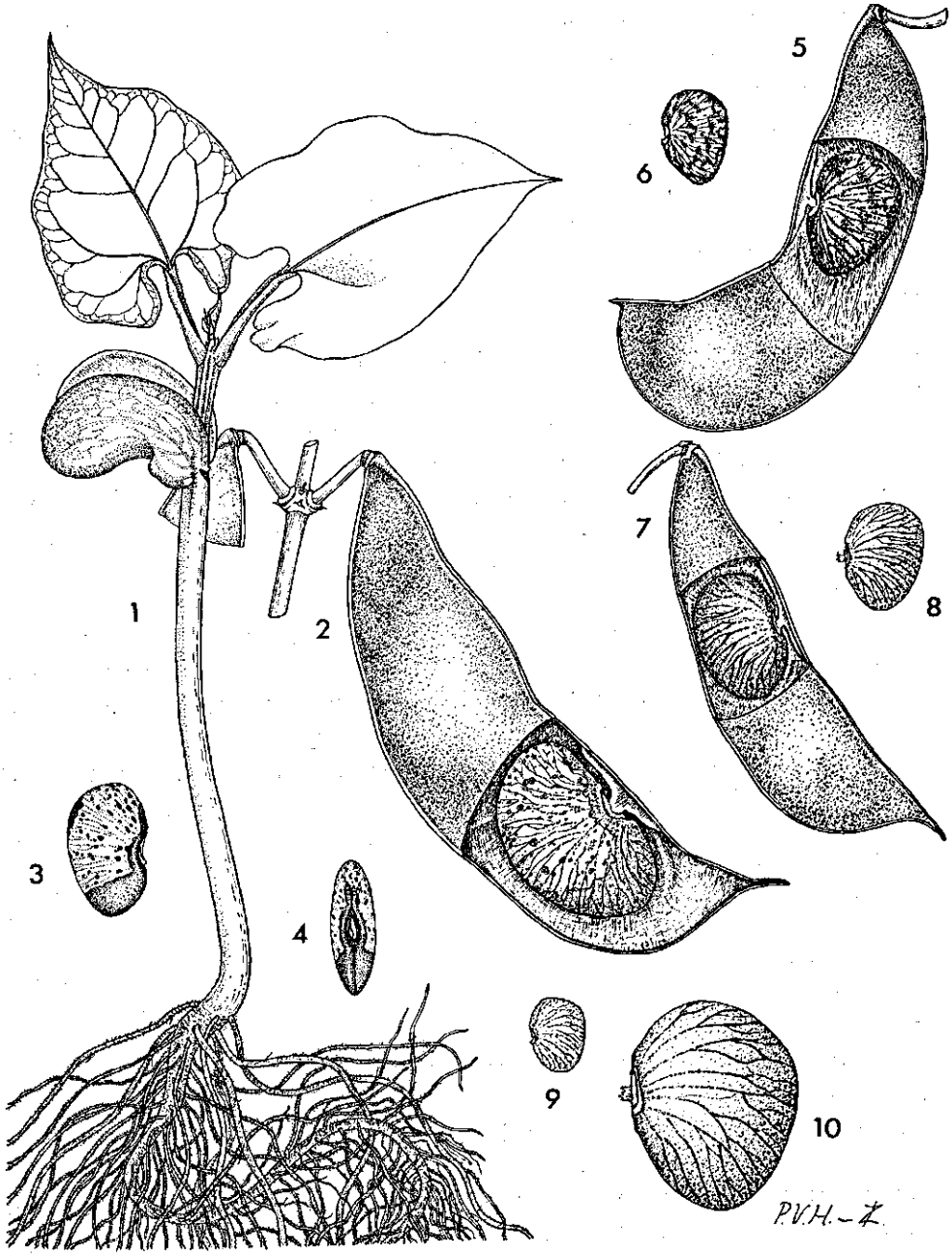

Fig. 16. *Phaseolus lunatus* L. cv. Harar Mosaic. – 1. seedling (5/6×); 2. pod (5/6×); 3. seed, lateral view (5/6×); 4. seed, with hilum (5/6×). Cv. Serbo Mosaic. – 5. pod (5/6×); 6. seed, lateral view (5/6×); 7. pod (5/6×); 8. seed, lateral view (5/6×). Cv. Wenago Purple. – 9 (5/6×). Cv. Assendabo Virgin. – 7. pod (5/6×); 8. seed, lateral view (5/6×). Cv. Wenago Purple. – 9 (5/6×). Cv. Assendabo Virgin. – 1. WP 7906 (spirit mat.); 2. WP 7908 (spirit mat.); 3–4. WP and 10. seed, lateral view (5/6×, 2 1/2×). – 1. WP 7906 (spirit mat.); 2. WP 7908 (spirit mat.); 3–4. WP 7908; 5. WP 8614 (spirit mat.); 6. WP 8614; 7. WP 8619 (spirit mat.); 8. WP 3368B; 9–10. WP 8586.

adaxially with fine patent hairs below the stigma. Stigma ellipsoid, directed adaxially, glandular, orange-yellow.

Pod widely varying in size, as a rule broadly sword-shaped, laterally compressed, slightly bulging over the seeds (not septate), (5.0–)5.5–12.0(–14.0) × (1.3–)1.5–3.0 cm, beaked, sometimes with a hook-shaped top, with dorsal suture ridged and ± flat and uneven, with pod wall ± striate, slightly pubescent to glabrescent, light brown, sometimes with red-brown spots, (1–)2–3-seeded.

Seeds variable in size, shape and colour, kidney-shaped or ± rhomboid, as a rule laterally compressed, (10–)12–24(–27) × (7–)9–13 mm, white, white with one red-purple ending and otherwise spots or mosaic (large-seeded types), red-purple, red-purple with lighter coloured spots, brown, brown to red-purple with darker coloured mosaic, whitish with purple mosaic, white with violet mosaic, sometimes nearly violet, white with black mosaic, sometimes nearly black, violet, or dark violet to black (medium and small-seeded types). Hilum sunken, oblong to ± elliptic, 2–4 mm long, covered by a layer of white, rather adherent tissue, light brown, with transverse lines radiating from the hilum to the opposite edge of the seed, with a twin-bump situated at the opposite side of the hilum where the micropyle is situated. Cotyledons whitish to dull yellowish.

Seedling with epigeal germination. Root system well-developed. Cotyledons ± sickle-shaped, thick; lower surface slightly grooved. Hypo- and epicotyl slightly pubescent, as a rule green. First two leaves simple, (deeply) cordate, (5.0–)6.0–7.5(–8.5) × (3.0–)3.5–4.5(–5.5) cm, acuminate at top, slightly pubescent to glabrescent. Stipulae of the two leaves as a rule partly connate. Petiole short, grooved above, slightly pubescent. Stipellae as a rule absent.

Note

Plants raised in the greenhouse in Wageningen under long-day circumstances produced luxurious vegetative growth, but did not flower and fruit, except for WP 7902–7903 and WP 7907–7908. Under short-day (11 hours) all other plants flowered and produced fruits.

Taxonomic notes

(1) In LINN no specimen of *Phaseolus lunatus* L. is present. Linnaeus cited in Sp. Pl. ed. 1 as the first reference Berg. viadr. 99. In his 'Catalogus stirpium...quas hortus medicus academiae Viadrinae complectitur' Von Bergen (1744) only gives a description: '*Phaseolus* Bengalensis scandens siliqua acinaciformi semine ovato compresso striato.' No plate is present. Since no other original sources used by Linnaeus in describing his *P. lunatus* are available, a neotype has to be designated. I have selected Westphal 8622 grown from seeds collected in Ethiopia. The specimens were grown at Wageningen in the greenhouse, and duplicates were distributed to Kew and Paris.

(2) The present commercial types of *P. lunatus*, according to Van Eseltine (1931), are distinguished as follows.

(a) The sieva which is comparatively thin-podded and 3–4-seeded.

(b) The large lima which is thicker-podded and 4–8-seeded.

(c) The potato lima with pods as short as sieva pods and few-seeded, but the pods are as thick as the large lima.

The seeds of the potato group are more nearly spheroidal than those of the other groups, the true limas being rather flat and the sievas varying considerably between the two extremes. Both large limas and sievas occur as pole beans and as bush beans.

Pre-Linnaean botanical literature lists various forms of the lima bean under a variety of names. Linnaeus in Sp. Pl. ed. 1 (1753) distinguished two species: *P. lunatus* and *P. inamoenus*. The sieva type is obviously what was intended by Linnaeus in his *P. lunatus* and was so understood. From specimens present in the British Museum and collected in botanic gardens in Europe in the 18th century (specimens collected by Miller, Jacquin), it is evident that *P. lunatus* L. is the small-podded and small-seeded lima bean. Post-Linnaean species may be included in two groups: the large-podded and the small-podded lima beans. Distinctions made by the various botanists were based on characteristics that do not justify specific rank (Mackie, 1943). The basic distinctions included vine variations (bush, vine, and intermediate), annual and perennial habit, leaflet form (willow leaf, large and small size), size and shape of pod, pod points, number of seeds per pod, warty serrations on pod sutures, seed coat colour distributions, radiations from the hilum, shape of seed (including flat, oval and others).

A post-Linnaean chronological list of lima bean species has been compiled by Van Eseltine (1931). De Candolle (1825), for example, included as distinct species besides *P. lunatus* L., the reddish-lined *P. inamoenus* L., the black-seeded *P. derasus* Schrank, the varicoloured seed forms of *P. xuaresii* Zucc., the very large-podded *P. macrocarpus* Poir., the Venezuelan *P. puberulus* H.B.K., and the Indochinese *P. tunkinensis* Lour. *P. macrocarpus* Moench is cited as a synonym of *P. inamoenus* L. Bentham (1862) attempted to segregate the larger-podded form from the smaller, naming the former one *P. lunatus* var. *macrocarpus*, and he assumes that *P. lunatus* L. and *P. bipunctatus* Jacq. apply to the thinner-podded form, whereas *P. inamoenus* L., *P. puberulus* H.B.K., *P. saccharatus* Macf. and *P. xuaresii* Zucc. (at least as described in DC., Prodr.) are thought to apply to the large lima type. Bailey (1927, 1941), following Linnaeus, recognized two forms: the large-podded type, which he listed as *P. limensis* Macf., and the small-podded types, which he included under *P. lunatus*. Piper (1926) stated that *P. lunatus* is a very diverse aggregate of both wild and cultivated forms whose status is variously interpreted by different botanists. He judges that they belong a single species. Van Eseltine (1931), who agreed with Piper's concept of a single species for lima beans, devised five formae to include the many variations. These five formae, which appear to be six if the sieva or small-podded lima is included, offer no more marked or serviceable distinction for botanical rank than do the usual horticultural cultivars (Mackie, 1943).

I suggest to distinguish within the cultivated *P. lunatus* L. the small-seeded types, being cv.-group Lunatus, and the large-seeded types, being cv.-group Inamoenus. Cv.-group Lunatus has been typified (see above). Cv.-group Inamoenus is typified as follows: in LINN no specimen is present of *Phaseolus inamoenus*. Linnaeus cited in Sp. Pl. ed. 1 as the only reference Hort. Cliff. p. 359, and indicated that the description

of this taxon there is a good one. The description of fruits and seeds is as follows: 'Legumen magnum, semina lineis rubicundis variegata'. No specimen is present in the Clifford Herb. or in LINN, however, and since Linnaeus cited no other references a neotype has to be designated. I have selected Westphal 8652, grown from seeds collected in Ethiopia. The specimens were grown at Wageningen in the greenhouse, and duplicates were distributed to Kew and Paris.

Synonyms for cv.-group Inamoenus are

Phaseolus inamoenus L., Sp. Pl. ed. 1: p. 724 (1753) (basionym).
Phaseolus rufus Jacq., Hort. Vindob. 1: p. 13 (1770).
Phaseolus macrocarpus Moench, Meth. Pl.: p. 155 (1794).
Phaseolus macrocarpus Poir., in: Encycl. Méth. Suppl. 3: p. 6 (1813).
Phaseolus limensis Macf., in: Fl. Jam. 1: p. 279 (1837).
Phaseolus lunatus L. var. *macrocarpus* (Moench) Benth., in: Fl. Bras. 15: p. 181 (1859-1862).

For more synonyms see Van Eseltine (1931).

(3) Asian grown cultivars were classified some time ago and their degree of toxidity was determined (Bull. imp. Inst. Lond. 10 (1912)).

(a) Java beans: medium-sized, rather flat, somewhat shrivelled beans varying in colour from dull purplish-red to nearly black. A few white beans are sometimes present. These beans yield comparatively large quantities of hydrocyanic acid when ground and moistened with water. This type of *P. lunatus* is only suitable as green manure, and where it is so used cattle should not be allowed near the fields where it is grown.

(b) Red Rangoon or red Burma beans: small, reddish beans, which are usually plump and occasionally show purple spots. They contain minute and usually harmless amounts of hydrocyanic acid when ground into flour and mixed with water.

(c) White Rangoon or white Burma beans: small, white beans, usually plump and resembling small haricots in appearance. The beans generally yield mere traces of hydrocyanic acid when ground into flour and mixed with water.

(d) Lima beans: large, plump, white beans, largely grown in the U.S.A., Madagascar and elsewhere as a vegetable. They generally do not contain hydrocyanic acid. This type is safe for human consumption.

(4) Pod and seed dimensions of the Ethiopian material.

The large-seeded pods	pod length:	(7.0–)9.5–12.0(–14.0) cm.
	pod width:	(2.0–)2.5–3.0 cm.
	seed dim.:	(17–)21–24(–27) × (10–)13(–16) mm.
The small/medium-seeded pods	pod length:	(5.0–)5.5–7.0(–8.0) cm.
	pod width:	(1.3–)1.5–1.7(–2.2) cm.
	seed dim.:	(10–)12–15(–18) × (7–)9–11(–13.5) mm.

(5) The following seed types are distinguishable in the Ethiopian material.

(1) Within cv.-group Inamoenus

(a) Seeds white. I designate this taxon as cv. Alemaya Light (based on WP 2315, WP 7901, WP 7902 and WP 7903).

(b) Seeds white with red-purple spots or mosaic. I designate this taxon as cv. Harar Mosaic

(based on WP 3514, WP 8632 and WP 8633).

(2) Within cv.-group Lunatus

(a) Seeds brown. I designate this taxon as cv. Maji Moon (based on WP 8569A, WP 8647, WP 8648 and WP 8649).

(b) Seeds brown + mosaic. I designate this taxon as cv. Didessa Mosaic (based on WP 3382, WP 7919, WP 8621 and WP 9822).

(c) Seeds red-purple. I designate this taxon as cv. Wenago Purple (based on WP 2820, WP 8584, WP 8585 and WP 8586).

(d) Seeds red-purple + mosaic. I designate this taxon as cv. Serbo Mosaic (based on WP 3254A, WP 7909, WP 8613 and WP 8614).

(e) Seeds whitish with purple mosaic. I designate this taxon as cv. Wollamo Speckle (based on Sl 1552D).

(f) Seeds dark violet-black. I designate this taxon as cv. Black Moon (based on Sl 1552E).

(g) Seeds larger and flat, red-purple. I designate this taxon as cv. Assendabo Virgin (based on WP 3368B, WP 7919, WP 8618 and WP 8619).

(h) Seeds larger and flat, violet. I designate this taxon as cv. Tewodros Pride (based on Sl 1552F).

(i) Seeds larger and flat, whitish with violet mosaic, sometimes nearly violet. I designate this taxon as cv. Girmane (based on Sl 1552G).

(j) Seeds larger and flat, whitish with black mosaic, sometimes nearly black. I designate this taxon as cv. Ras Teferi (based on Sl 1552H).

(6) The following differences were found between plants raised at Wageningen and in Ethiopia.

	Wageningen	Ethiopia
leaf: rachis	(2.0–)2.5–4.0(–8.0) cm	(1.5–)2.0–3.0)–4.5) cm
leaflet: length	(6.0–)7.5–13.0(–19.5) cm	(5.5–)7.0–10.0(–12.5) cm
width	(4.0–)5.0–8.5(–11.0) cm	(3.0–)4.5–6.0(–8.0) cm
peduncle	(1.0–)2.0–7.5(–12.5) cm	(0.5–)4.5–7.5(–9.5) cm
rachis	(0–)4.0–7.5(–18.0) cm	(0–)2.0–8.0(–13.0) cm

(7) The description is based on the following specimens.

Shoa	Awash Station, garden Buffet de la Gare: WP 1971; 3 km past Awasa on Shashamane road, in garden: WP 2603, WP 2604.
Wellega	Shankalla market, near Didessa river on Gimbi road: WP 3382; near Yubdo, on market: Sl 1552.
Illubabor	Yamba market: WP 8570A–WP 8570D; Tepi, in garden: F. G. Meyer 8904 (also at K!).
Kefa	Assendabo market: WP 3368A, WP 3368B; Serbo market: WP 3254A, WP 3254B; Jima, in fence near house: F. G. Meyer 7813 (K!); Agaro market: Sl 91; Maji market: WP 8569A–WP 8569C.
Gamu Gofa	1½ km past Gidole on Arba Minch road, in garden: WP 3209.
Sidamo	114 km past Agere Selam on Kebre Mengist road, in garden: WP 2719; Dila, in garden: WP 2836; 12 km past Dila on Wenago road, in garden: WP 2820; 42 km past Soddo on Shashamane road, in garden: WP 2873; 31 km past Soddo on Arba Minch road, in garden: WP 2974.
Hararge	Gelemso market: Sl 616; 17 km past Harawacha on Gergertu road, in fence of garden: WP 2539; Alemaya, in garden: WP 381, WP 2315; 4 km past College entrance on Kombolcha track: WP 663; 1½ km past College en-

trance on Kombolcha track, in field: WP 2334; around Harar, in garden: WP 3514.

Grown at Wageningen WP 6185, WP 6186, WP 6275, WP 6276, WP 6680–WP 6683, WP 6765, WP 6766, WP 7188, WP 7901–WP 7922, WP 8584, WP 8586, WP 8613–WP 8616, WP 8618, WP 8619, WP 8621, WP 8622, WP 8633, WP 8647–WP 8652.

Ecology

The lima bean needs a frost-free growing season and dry weather for maturing the seeds. Pole cultivars require a longer season than bush cultivars. It is found in the tropics up to 1800–2400 m altitude. The sieva group includes cultivars more resistant to hot, arid conditions than the large lima group, so that many of the sievas grow in the more continental climates of the American interior and are spread over a wide range in North, Central and South America (Mackie, 1943). They are fairly drought-resistant. Some cultivars fail to set seed during very hot weather and seed set is reduced above ca 28 °C. They will tolerate more rain during the growing season than *P. vulgaris*. Lima beans need well-drained, well-aerated soils, are sensitive to high acidity and prefer a pH of 6–7. Heavy soils prone to water-logging are detrimental for growth. Some cultivars and wild plants of the Carib-type are short-day plants; the other groups are day-neutral. Lima beans are not as tolerant of adverse conditions as many of the other cultivated species of *Phaseolus* (Purseglove, 1968).

In Ethiopia the lima bean is cultivated below ca 2000 m altitude in the high rainfall areas of the south-western region. If enough water is available it is also found in Hararge.

Husbandry

The crop is planted at the beginning of or during the first part of the rains in rows 75–100 cm apart. Distance in the row varies from 10–50 cm according to type; the large seeds are planted at up to 8 cm deep. Young pods may be harvested three months after sowing. The beans normally mature after 5–7 (rarely 9) months and the harvest may continue for several months. The lima beans ripen irregularly; they should be harvested before the pods are completely brittle as they are liable to shatter when fully ripe. The pods are then dried on trays and threshed. In Africa, except in Madagascar, they are a garden or compound crop. The Madagascar cultivar ('kabara') occupies some 3000 ha. It is cultivated on alluvial soils along the rivers and is sown from March to May, when the rivers recede, in holes 25–40 cm deep (depending on soil moisture). The spacing is 1.5–5 m square. This receding-flood method of planting may be applicable to other parts of Africa (Stanton et al., 1966).

In India, at the beginning of the monsoon rains, 2–3 seeds are planted per hill about 150 cm apart in rows spaced at the same distance. About 8–10 kg of seeds are required to sow a hectare. Germination takes place in 5–6 days; weeding and irrigation depend on the local conditions. From October onwards till the harvest of the crop

irrigation at an interval of 8–10 days is desirable. The supported crop starts flowering 11–12 weeks after sowing and in another 4 weeks the pods are ready for picking. Subsequent pickings can be carried out at an interval of ca 2 weeks. A crop gives 12–14 pickings yielding 5000–8000 kg of green pods and 200–300 kg of dry seeds per ha (Singh et al., in: Kachroo, 1970).

In the U.S.A. bush cultivars are sown at 70–90 × 5–20 cm, pole cultivars in hills 90–120 cm apart, with 3–4 seeds per hill. The seeds are put at a depth of 2.5–5 cm, 135–170 kg/ha for the large-seeded cultivars, 55–80 kg/ha for the small-seeded ones. Early maturing cultivars are harvested from about 100 days onwards, whereas late maturing ones take up to 7–9 months and give a crop over a long period. Yields are up to 1350 kg/ha of dry beans (Purseglove, 1968).

In Ethiopia lima bean is solely cultivated as a garden crop.

Uses

Lima bean is grown for the young pods, the young and the ripe seeds, and sometimes the young leaves are eaten. Care is required in the preparation of the ripe seeds as some cultivars contain dangerous quantities of hydrocyanic acid. The white-seeded cultivars are considered safer in this respect, and are usually non-toxic after cooking, whereas the coloured-seeded ones have to be boiled several times, and the cooking water has to be renewed. The green-shelled beans are cooked as a vegetable; so are the young pods and leaves. In the U.S.A. the green beans are canned and frozen. The seeds are sometimes used for making taogé (bean sprouts), which are eaten cooked; they are after cooking not toxic anymore (Purseglove, 1968; Terra, 1966).

The crop has been used as a cover crop of short duration, and as green manure. The dwarf cultivars serve best as a cover crop, since the climbing forms tend to smother the main crop. The vines can be used as fodder (Burkill, 1966). The Madurese of Indonesia use them as hay in the dry season; when fresh they may possibly be poisonous (Heyne, 1927). In Ethiopia the seeds are eaten.

Protein content

Leaves: 3–7.5% (Terra, 1966); young pods: 2.5–3% (Terra, 1966); young seeds: 6.5–10.5% (Terra, 1966), ca 7.5% (Purseglove, 1968); ripe seeds: ca 20% (Terra, 1966).

No limiting amino acids are recorded (Aykroyd & Doughty, 1964).

(10C) Phaseolus radiatus L. **Fig. 17; Plate 25**

'*Phaseolus*': see *Phaseolus coccineus*.
'*radiatus*': from Lat. radius = spoke or ray, and so: radiant towards every direction, like the spokes in a wheel.

Linnaeus, Sp. Pl. ed. 1: p. 725 (1753).
Type: from Ceylon; '*Phaseolus* zeylanicus siliquis radiatim digestis' of Dillenius, Hort. Elth.: p. opposite p. 314, tab. 235/304 (1732) (lecto.!).

Synonyms

Phaseolus aureus Roxb., Flora Indica 3, ed. Carey: p. 297 (1832).
Phaseolus mungo Roxb., Flora Indica 3, ed. Carey: p. 292-295 (1832).
Phaseolus radiatus var. *typica* Prain, J. Ass. Soc. Beng. 66: p. 422 (1897).
Azukia radiata (L.) Ohwi, in: Fl. Japan: p. 691 (1953) and in: Bull. Nat. Sci. Mus. Tokyo 33: p. 77 (1953).
Vigna radiata (L.) Wilczek, in: Fl. Congo Belge 6: p. 386 (1954).
Rudea aurea (Roxb.) Maekawa, J. Jap. Bot. 15: p. 114 (1955).
Vigna mungo sensu Hepper, non L., in: Fl. West Trop. Africa ed. 2, 1: p. 569 (1958).
Vigna radiata f. *aurea* (Roxb.) Ohwi & Ohasi, J. Jap. Bot. 44: p. 30 (1969).
Vigna radiata var. *radiata* (L.) Verdc., Kew Bull. 24(3): p. 559 (1970).

Literature

1897: Prain, J. Ass. Soc. Beng. 66: p. 422-423. (tax.)
1914: Piper & Morse, Bull. U.S.D.A. 119: p. 16-18. (tax.)
1917: Harms, Notizbl. bot. Gart. Mus. Berl. 7: p. 107-108. (tax.)
1927: Heyne, Nuttige planten Ned. Indië 2: p. 836-838. (agric.)
1937: Dittmer, in: Vavilov & Wulff, eds, Koultournaja Flora SSSR 4: p. 573-601. (tax.)
1953: Whyte et al., Legumes in agriculture: p. 303-304. (agric.)
1958: Leese, Am. Midl. Nat. 60: p. 138-140. (tax.)
1964: Aykroyd & Doughty, Legumes in human nutrition: p. 108, 118. (agric.)
1966: Burkill, A dict. ec. prod. Malay Peninsula 2: p. 1735-1736. (agric.)
1966: Terra, Tropical vegetables: p. 65-66. (agric.)
1968: Purseglove, Tropical crops, Dicotyl. 1: p. 290-294. (agric.)
1970: Singh, Joshi & Thomas, in: Kachroo, ed., Pulse crops of India: p. 136-148. (agric.)
1971: Verdcourt, in: Flora Trop. East Africa, Leg. 4, Papil. 2: p. 655-656. (tax.)

Local names: fudjeelee (Gallinia); maaisjo (?); ogodde (Anyowah).
Trade names: mung (Hindi); green gram, golden gram, mung bean (English); ambérique (French).

Geographic distribution

This plant is not found in a wild state, but Prain (1897) is inclined to think that it is a cultivated derivative of *P. sublobatus* Roxb., which grows wild in India where it is occasionally cultivated. This species even may be regarded as the progenitor of both green gram (mung) and black gram (urd). The crop is of ancient cultivation in India and numerous cultivars are known in this area. It is an early introduction in southern China, Indo-China and Java. Green gram has been brought in comparatively recent times to East and Central Africa, the West Indies and the U.S.A. In Africa, however, it is grown only sporadically (Purseglove, 1968; Stanton et al., 1966).

In Ethiopia it is a recent introduction and has been met with only in the markets of Hararge, Nazret and Gamu Gofa, and sometimes in fields in west Illubabor.

Description

An erect to sub-erect, much-branched, (slightly) pubescent annual, with well-developed taproot.

Stems ± square, slightly ribbed, sometimes twisting, hollow, hispid (hairs straight, glossy, bristle-like, a capillary cell on a ± swollen base, with tip sharp or blunt, apparently containing a brown substance which may be excreted) (see note).

Stipulae prominent, peltate, (ob)ovate, sometimes appendaged or spurred, acuminate, with prominent venation, with edge ciliate.

Leaves alternate, 3-foliolate. Petiole (5.0–)10.0–15.0(–18.0) cm long, grooved above, (slightly) pubescent. Rachis (1.5–)2.0–3.0(–4.5) cm long, grooved above, slightly pubescent, topped by a leaflet.

Leaflets: First two leaflets opposite and asymmetrical, top leaflet symmetrical, shortly-petioluled (ca 5 mm long) with indumentum as a rule denser than on petiole, (broadly) ovate, (5.5–)6.5–10.0(–12.5) × (3.0–)4.0–6.5(–10.0) cm, entire, cuneate at base, acuminate and mucronulate at top, palmately 3-nerved and green and glabrescent–thinly pubescent above, grey-green below with venation more prominent.

Stipellae prominent, ca 5–10 mm long, glabrescent, at the base of the petiolule; one per lateral leaflet, narrowly ovate, with flagelliform top, sometimes a second much narrower and smaller stipella present; two per top leaflet, similar in shape to the lower stipellae though often smaller and often each of them also accompanied by an almost subulate additional stipella.

Inflorescence an axillary raceme with several flowers clustered at the top. Peduncle (3.5–)4.5–9.0(–15.5) cm long, slightly twisted, ribbed, pubescent when young, gradually glabrescent. Rachis contracted, glabrous or nearly so, with few tubercles; flowers arising 1–3 together; bracts one per flower, early deciduous, ovate, 4–5 mm long, acuminate, with light coloured venation, with edge ciliate; pedicels very short, glabrescent, with two prominent bracteoles attached at the base of the calyx. Bracteoles subpersistent, narrowly triangular, ca 5 mm long, with edge ciliate.

Calyx campanulate, glabrous, except for the short-ciliate lobes; tube ca 4 mm long, with base somewhat fleshy becoming shallowly saucer-shaped when older while carrying the thin upper calyx-lobes; lobes 5, the upper pair of lobes connate forming an emarginate lip, the other three lobes subequal, triangular, ca 2.5–4 mm long, top acute.

Corolla: Standard with lower part (claw) directed forward, upper part (limb) erect above a deep sinus, with top directed backwards and edges slightly connate forming an enclosure for the upper part of the wings and the upturned top of the keel, hood-shaped, transversely broadly elliptic, ca 11 × ca 14 mm, clawed, bi-auriculate, with auricles inflexed, with a prominent 'pocket' right above the claw, emarginate at top, glabrous, yellow. Wings broadly falcate, ca 11 × ca 7 mm, clawed, with a widely projected, rather fleshy auricle (sometimes two auricles present), with dorsal edges above the auricle inflexed, striate, resting against the standard 'pocket', rounded at top, glabrous, yellow, at the base adherent to the keel. Keel sharply upturned suggesting an elephant's trunk, ca 10 mm long, clawed, weakly auriculate, dorsally and ventrally split near the base, with a conspicuous 'pocket', with the apex incurved (forming a half spiral), not connate at top (stigma just exserted), glabrous, green-yellowish.

Androecium: Stamens diadelphous (9 + 1). Vexillary stamen free, ca 15 mm long, tapering towards the top, geniculate at base, with upper part upturned and curving.

Staminal sheath winged, with wings rather fleshy, ca 7 mm long, upturned like a swan's neck; free part of filaments irregularly released, slightly winged towards the base, otherwise filiform, kinked. Anthers ellipsoid, ca 0.5 mm long, basifixed, pale yellowish-brown.

Disk collar-shaped, ribbed, ± repandous.

Gynoecium: Ovary sessile, ca 7 mm long, curved, densely finely pubescent, 7–13-ovulate. Style upturned, once twisted and kinked, with lower part slightly winged, flexible, and upper part cartilaginous, with slender beak beyond the stigma, with a narrow fringe of fine patent hairs below the stigma directed adaxially. Stigma conspicuous, ellipsoid, directed adaxially, glandular, orange-yellow.

Pods as a rule linear-cylindrical, slightly bulging over the seeds, 6.0–9.0 × ca 0.5 cm, beaked, dark brown, bristly, lax-pubescent, septate, (7–)11(–13)-seeded, dark brown to blackish when mature.

Seeds small, broadly ellipsoid to globular, sometimes ± square-cylindric, 2.5–5 × 3–4 mm, usually dull green, sometimes light brown; seed coat sometimes mealy, and under magnification usually marked with fine wavy ridges with close parallel riblets perpendicularly in between causing the seed to be somewhat rough to the feel. Hilum narrowly elliptic, ± half of the longest dimension, ± central, covered by a layer of white detachable tissue, brownish-green; aril absent; with a twin-bump forming a ridge at the opposite side of the hilum where the micropyle is situated. Cotyledons dull pale yellow.

Seedling with epigeal germination. Root system delicate, with numerous laterals. Cotyledons ± oblong, with ridges ventrally, sometimes purplish. Hypo- and epicotyl pubescent, green or purple. First two leaves simple, narrowly ovate, (2.5–)3.0–4.0 (–4.5) × (1.0–)1.2(–1.4) cm, acute at top, with edges ciliate. Stipules of the two leaves partly connate, subulate. Petiole short, pubescent. Stipellae absent.

Note

Plants raised from seed sample WP 2996 show hairs with a blunt tip, whereas plants grown from the other seed samples show sharp-tipped hairs.

Taxonomic notes

(1) In Sp. Pl. (1753) Linnaeus, in describing *P. radiatus*, refers to some of his earlier works: Acta Stockh. (1742) which includes a drawing, Hortus Upsaliensis (1748) and Flora Zeylanica (1746). In Hort. Ups., Linnaeus states that his plant was grown in the greenhouse at Uppsala. In Flora Zeylanica he refers to Museum Zeylanicum of Hermann (1717) where the plant was named 'mun' or 'mung'.

Important is Linnaeus's additional reference (l.c.) to Hortus Elthamensis of Dillenius (1732), where a *Phaseolus* was described and depicted. In LINN a specimen of *P. radiatus* (nr 899.8) is present, but without the usual number corresponding with Sp. Pl. ed. 1. It is a specimen with flowers and very young fruits.

According to Piper & Morse (1914) the plant Linnaeus grew in Uppsala and which

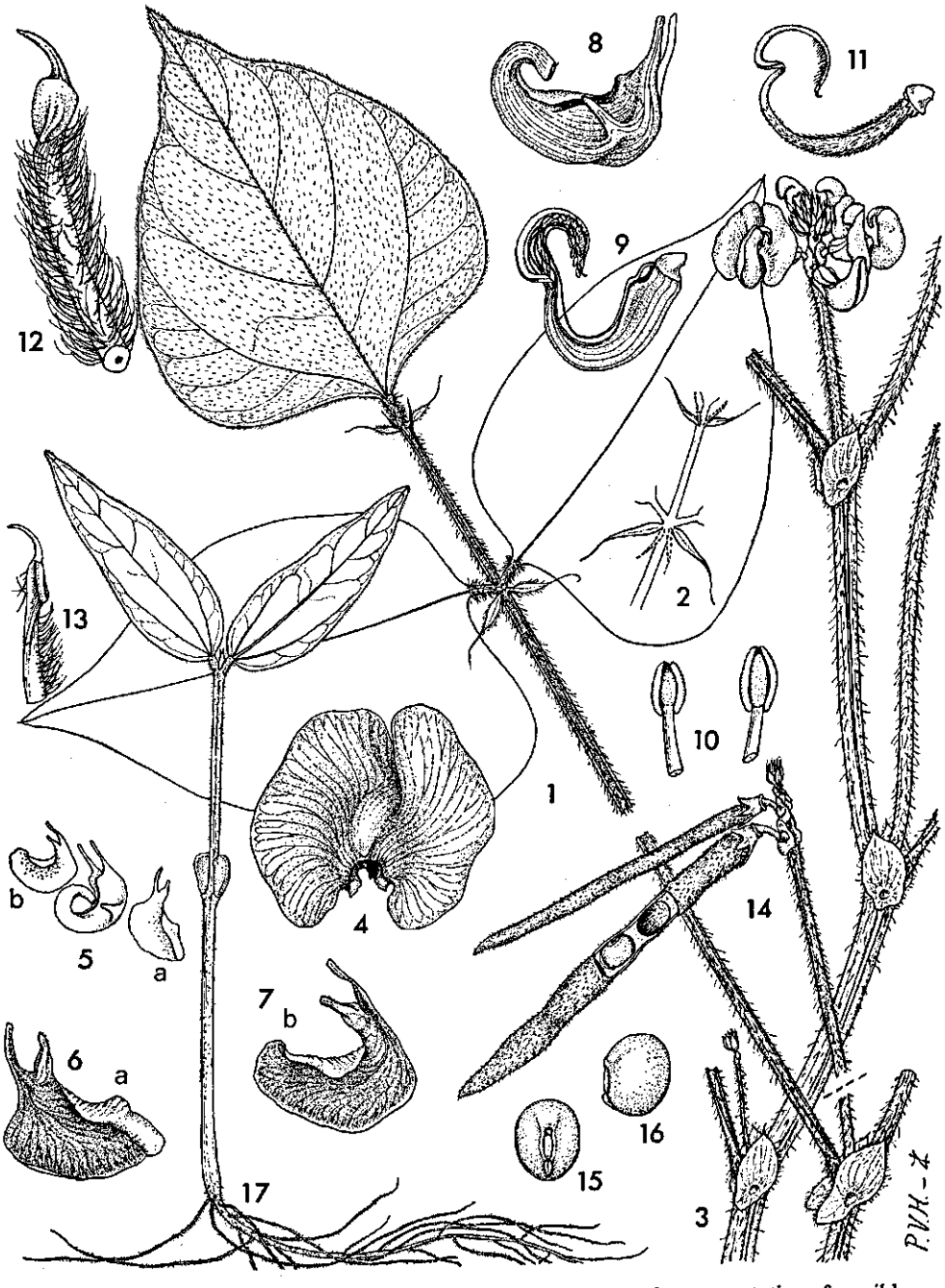

Fig. 17. *Phaseolus radiatus* L. cv. Nazret Mung. – 1. leaf (5/6×); 2. schematic representation of possible stipellae, 0–4 dotted stipellae may be present extra; 3. branch with inflorescence (5/6×); 4. standard, adaxial view (2½×); 5. schematic representation of keel and wings (a) and (b); 6. wing (a), adaxial view (2½×); 7. wing (b), adaxial view (2½×); 8. keel (2½×); 9. staminal sheath (2½×); 10. anthers (15×); 11. pistil + disk (2½×); 12. style + stigma (15×); 13. stigma (10×); 14. pods (5/6×); 15. seed, with hilum (2½×); 16. seed, lateral view (2½×); 17. seedling (5/6×). – 1. WP 7890; 3. WP 7889 (spirit mat.), WP 7894; 4–13. WP 8589 (spirit mat.); 14. WP 7890 (spirit mat.); 15–16. WP 2996; 17. WP 7888 (spirit mat.).

constitutes the type of his *Phaseolus radiatus* is not the same as the one Dillenius described and figured (and which is the mung bean). In their opinion it is what later on has been called *P. sublobatus* Roxb. They conclude that there exists no botanical name given by Linnaeus that can properly be applied to the mung bean. Modern nomenclature rules, of course, do not support Piper & Morse.

Harms (1917) is of the opinion that, nevertheless, the name *P. radiatus* L. can be used for the mung bean, since the description of Linnaeus is based on the plant depicted and described by Dillenius, and which also has been accepted by Piper & Morse as being the mung bean. That, in the opinion of Piper & Morse, the original specimen is not the mung bean but *P. sublobatus* Roxb, is no reason to reject Linnaeus's name *P. radiatus*. In addition, the description of Linnaeus does not include any element that excludes the mung bean from the described taxon. Under the circumstances Verdcourt's decision to designate Dillenius's plate (Hort. Elth.: p. 315, t. 235, f. 304) as the lectotype of *P. radiatus* L. is followed, although it might be remarked that Acta Stockh. (1742) is cited by Linnaeus as the first reference and therefore is the most important base for the name *P. radiatus*. The Acta contain a full description and a plate and might have been accepted as the lectotype. However, Dillenius's plate[14] and description are more detailed and so possibly more readily acceptable.

(2) The mung bean collected in Ethiopia is given the name cv. Nazret Mung (based on WP 2996, WP 7888, WP 7889 and WP 7890).

(3) There has been a great confusion on the proper botanical name that should be applied to the 'mung' (see above). The mung bean was well-known previous to Linnaeus's time, having been described by various botanists and well-figured by Dillenius. However, matters are complicated by the fact that a close relative of the 'mung', being 'urd' or 'mash' (or 'mash-kulai'), has been confused by Linnaeus with the 'mung' when he described *P. mungo* (Mant. p. 101 (1767)).

The unfortunate thing, according to Prain (1897), is that the name which Linnaeus gave to the 'mung', viz. *P. radiatus*, as is shown by his diagnosis and his reference to Dillenius's figure, does not conserve the vernacular name of the plant. This would not have mattered much if Linnaeus had not, at a later date (1767), used the epithet 'mungo', to designate not 'mung', but 'tikari', a form of 'urd' (see Linnaeus's description in Mantissa Plantarum: p. 101 (1767); no specimen present in LINN).

Roxburgh (1832) described and named a number of species and varieties of *Phaseolus* grown in India. He changed the application of Linnaeus's names in several respects, applying the name *P. mungo* to the green-seeded 'mung', *P. max* to the black-seeded 'mung', and *P. radiatus* to the 'urd'. He also named the golden-seeded 'mung' *P. aureus*. These changed applications of Roxburgh are not acceptable.

Baker's account of the species of *Phaseolus* in the Flora of British India (1879)

14. In the library of the Britisch Museum (Dept. of Botany) Hortus Elthamensis is present with coloured plates. '*Phaseolus* zeylanicus ...' is depicted here with violet flowers which is not in agreement with the botanical description (l.c. p. 315). So the colour has to be attributed to the artist's imagination.

follows Roxburgh's treatment. The *P. mungo* in the Flora of Br. India is Roxburgh's concept of *P. mungo* L., but is not the species Linnaeus described in 1767. Baker's *P. mungo* var. *radiatus* is Roxburgh's *P. radiatus*, and most certainly not *P. radiatus* L. Prain suggests that *P. trinervius* Heyne (an older name for *P. sublobatus* Roxb.) of the Flora is the wild form from which perhaps both 'mung' and 'mash' have originated, but at present all three deserve to be considered equally distinct.

The three leading varieties of 'mung' *(P. radiatus* L.*)* may be distinguished, according to Prain, as follows.

(a) Var. *typica* with dark green foliage, pods spreading, seeds green: the 'mung' (= *P. mungo* sensu Roxb.).

(b) Var. *aurea* with paler foliage, pods reflexed, seeds yellow: the 'sona mung' (syn. *P. aureus* Roxb.).

(c) Var. *grandis* with medium green foliage, pods spreading and longer, seeds black: the 'krishna mung' (= *P. max* sensu Roxb.).

(4) The habitus of the 'urd', *P. mungo* L. (= *P. radiatus* sensu Roxb.) is more or less similar to that of the 'mung'. The plants, however, are lower and spreading with usually procumbent branches, the pods are much shorter and stouter, erect or sub-erect, and very hairy with long hairs, and the seeds are longer, oblong and smooth, varying in colour from blackish to olive with a concave hilum and arillate. The 'mung' possesses pods which are spreading or reflexed with short hairs, and the seeds are globose with fine wavy ridges on the testa, and a flat hilum.

Prain (1897) distinguished two forms of *P. mungo* L.

(a) Forma *vera* with hirsute, scandent or subscandent stems and black seeds. This is, says Prain, the 'tikari' which stood for Linnaeus's description of *P. mungo*. Prain's interpretation was generally accepted afterwards. It is perhaps hardly distinct from the next.

(b) Forma *roxburghii* with hirsute, diffusely spread but not scandent stems and grey seeds. This is the 'urd' or 'mash-kulai', being *P. radiatus* sensu Roxb. It is a very important crop in India, more important than the 'mung'.

(5) Verdcourt (1971) is of the opinion that 'mung' and 'urd' are scarcely more than variants of one species but for long have been kept separate in India, and that it is practical to continue to do so until a monograph is attempted. Following Wilczek (1954) and Hepper (1956) respectively, Verdcourt places, nevertheless, 'mung' and 'urd' in *Vigna*, with the names *V. radiata* (L.) Wilczek and *V. mungo* (L.) Hepper. According to Verdcourt *P. sublobatus* Roxb., the possible progenitor of both 'mung' and 'urd', deserves only varietal rank within *Vigna radiata*. If it is decided to wait for a monograph on the genera *Phaseolus* L. and *Vigna* Savi, it seems premature to decide beforehand to transfer *P. radiatus* and *P. mungo* to the genus *Vigna*.

(6) The description is based on the following specimens.

Shoa	Nazret market: WP 2996.
Illubabor	in field, ± 30 km past Gambela to the border: SI 1541.
Gamu Gofa	Gidole market: WP 3231C; Kitili (Mursi), Lower Omo valley: Turton 37 (K!).

Hararge	Harar market: WP 3185; Feddis market: SI 170; Assabot market: SI 695.
Grown at Wageningen	WP 6886, WP 7888–WP 7894, WP 8589, WP 8590.

Note
The seed number WP 2509, collected at the College of Agriculture at Alemaya, is not included, since the seeds probably were introduced from the U.S.A.

Ecology

In India the crop is grown from sea level up to ca 1800 m. In submontane regions and in the outer ranges of the north-west Himalayas (up to ca 1800 m) it is grown as a 'summer' crop. Usually it is cultivated as a dry-land crop after rice. It develops best on medium loamy soils, and with a well-distributed annual rainfall of ± 750–± 900 mm. It is drought-resistant, but susceptable to water-logging (Purseglove, 1968; Sing et al., in: Kachroo, 1970). In India both short-day and long-day cultivars occur (Purseglove, 1968). This is, however, most unlikely; meant is that *P. radiatus* includes types which are short-day and day-neutral.

The cultivars collected in Ethiopia are short-day plants; one of them is a qualitative short-day cultivar (WP 3185).

Husbandry

The crop requires a good tilth. In India, when grown in pure stands, it usually precedes wheat, sugarcane or garden crops which are cultivated in the cold season of the same year. When 'mung' is sown under mixed cropping, the cultural practices for the main crop are adopted. In such cases it is generally broadcast (Singh et al., in: Kachroo, 1970). In Indonesia it is grown as a second crop on the sawahs and is sown immediately after the rice harvest in between the stubbles (Heyne, 1927).

The crop matures in 80–120 days, depending upon the cultivar and the season. Pods are picked at intervals; in some places the whole plants are uprooted and stacked. When the pods are picked the plants are generally ploughed in. Yields vary between 450 and 560 kg/ha, but over 1100 kg/ha have been recorded in the U.S.A. Pods have the tendency to shatter. Yields of air-dried hay in the U.S.A. are ca 2.5–6 tons/ha for golden gram, but less for green gram (Purseglove, 1968).

Uses

The cultivars, differing in habit, height, period to maturity, colour of pods, and size and colour of the seeds, can be divided into two main types.
(a) Golden gram ('sona mung') with yellow seeds, mainly used for pasture, hay, silage and as a cover crop, but good pulse cultivars occur in India; it is not a prolific seed producer and has the tendency to shatter.
(b) Green gram ('mung') with dark or bright green seeds, the latter used for sprout production; its cultivars are more commonly planted for the production of pulse, as

they produce more seeds and the pods ripen more uniformly and have less tendency to shatter (Purseglove, 1968).

The 'mung' is an important crop in India. The dried seeds are boiled and eaten whole or after splitting into dhal. They are parched and ground into flour after removing the testa, the flour being used in various Indian and Chinese dishes. Split seeds fried in a little fat and salted are eagerly consumed with tea or drinks as a snack. Sprouted seeds serve in south India to prepare curry or a savoury dish. In China and the U.S.A. the sprouts are also used: the seeds are soaked overnight, drained and placed in containers in a dark room, sprinkled with warm water every few hours and the sprouts may be harvested after about a week. Both the young pods and the young leaves are eaten as a vegetable (Purseglove, 1968; Singh et al., in: Kachroo, 1970).

On Java the plants are cut back some time after germination, the cut-off part serving as a vegetable. This leads to the free branching, already observed by Rumphius (1747). The haulms are used as fodder and the husks and split seeds are a useful food for livestock. In India the plants are uprooted after the pods have been harvested and chopped into pieces. The pods, after removal of the grain, are sometimes mixed with the chopped fodder. Occasionally, after the harvest, animals are let loose in the field to graze the denuded plants. The crop is also grown for hay, green manure and as a cover crop. It is ideally suited as a short duration crop on fallowed land (Purseglove, 1968; Singh et al., in: Kachroo, 1970).

As to Africa, recent studies suggest that the main problem in familiarizing this crop is to make people accept it. It may make a very useful contribution to the nutritional balance of the diet (Stanton et al., 1966).

In Ethiopia the seeds are used in sauces.

Protein content

Young leaves: ca 8% (Terra, 1966); dried seeds: 23.6% (Purseglove, 1968), ca 24% (Terra, 1966), ca 25% (Kachroo, 1970); bean sprouts: ca 2–6% (Terra, 1966).

The first limiting amino acids are methionine and cystine, followed by tryptophan (Aykroyd & Doughty, 1964).

(10D) Phaseolus vulgaris L.

Figs 18, 19; Plates 26–52

'*Phaseolus*': see *Phaseolus coccineus*.
'*vulgaris*': derived from Lat. 'vulgus', the common herd, the common people; common, of frequent occurrence.

Linnaeus, Sp. Pl. ed. 1: p. 723 (1753).
Type: a plant cultivated at Uppsala; '*Phaseolus* caule volubili, ..., bracteis majoribus, leguminibus pendulis' (LINN, specimen 899. 1, lecto.!).

Synonyms

Phaseolus esculentus Salisb., Prodr.: p. 335 (1796).

Literature

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1970: Choudhury, in: Kachroo, ed., Pulse crops of India: p. 234, 242-248. (agric.)
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Local names: adagora, adagura (Tigrinia); adigura-tsada, zada-adagonna (Tigrinia; small, white beans); adanguare, fajola, fosolia (Amarinia); fosolia-nech (Amarinia; white beans); ashanguare (Gallinia); salboco-bulluc (Somali); salboco-bulluc-adda (Somali, white beans); salboco-bulluc-ghedud (Somali, red beans).
Trade names: common bean, French bean, haricot, haricot bean, kidney bean, navy bean, pinto bean, runner bean, salad bean, snap bean, string bean (English); haricot commun, haricot (French); frijol común (Spanish).

Geographic distribution

Phaseolus vulgaris is the best known and most widely cultivated species of *Phaseolus* L. It originated in the New World and was domesticated in Mexico by some 7000 years

ago (Kaplan, 1965). Botanical explorations have shown that wild *P. vulgaris* grows in Mexico along the Sierra Madre Occidental and in Guatemala, where it occurs in an ecological transition belt ranging from 500–1800 m altitude (with the highest frequency of wild types at ca 1200 m). In the first region a great diversity is found; moreover the oldest archaeological remains of cultivated *P. vulgaris* have been found in the same area. These facts suggest that *P. vulgaris* had its centre of origin at some place in the western Mexico–Guatemala area (Miranda, 1968). Because of the varietal composition of archaeological *P. vulgaris* in Mexico and elsewhere and the degree of endemism, Kaplan (1965) and later Gentry (1969) suggest multiple domestication within Central America, from a widespread and polymorphic ancestral species.

In the Old World the common bean is not known with certainty until post-Columbian time. Spaniards and Portuguese took it to Europe, Africa and other parts of the Old World. It is now widely cultivated in many parts of the tropics and sub-tropics and throughout the temperate regions. *Phaseolus vulgaris* is the most important pulse crop throughout tropical America and many parts of tropical Africa. It is of little importance in India and most of tropical Asia, where indigenous pulses are preferred (Purseglove, 1968).

In Ethiopia it is mainly found in the Chercher area of Hararge, in the lower regions of Shoa and Arussi, and to a lesser extent in the south-west of the country. Dried seeds have been observed at the markets of Shoa (lower regions), Wellega (lower regions), Kefa, Gamu Gofa (e.g. Konso area), Sidamo, Arussi (lower regions) and Hararge.

Description

A climbing, vining or bushy, slightly pubescent annual with well-developed taproot, laterals and adventitious roots. Sometimes globular nodules present.

Stems terete or angular, sometimes hollow when older, sometimes twisted, thinly pubescent; hairs long and appressed short and thickened at base, white or brown.

Stipulae small, triangular, acuminate at top, with several slender, parallelous, lighter coloured length-nerves, slightly pubescent, with edges sometimes partly slightly ciliolate.

Leaves alternate, 3-foliolate. Petiole (6.0–)10.0–15.0(–32.5) cm long, with a marked dark green pulvinus, often hollow, grooved above, glabrescent, as is the rachis, (1.5–)2.5–3.5(–6.0) cm long, topped by a leaflet.

Leaflets: First two leaflets opposite and asymmetrical, top leaflet symmetrical, shortly-petioluled (ca 5 mm long), with indumentum distinctly denser than on petiole, ovate, rarely rhomboid, (5.5–)7.5–14.0(–20.5) × (4.5–)5.5–10.0(–15.5) cm, entire, as a rule truncate at base, sometimes cuneate, acuminate and often mucronate as well and sometimes rounded at top, palmately 3-nerved, as well as green and thinly pubescent above, grey-green with prominent venation below.

Stipellae small, linear, glabrous; 1 per lateral leaflet, 2 per top leaflet.

Inflorescence an axillary raceme with several to many flowers. Peduncle (0–)3.0–

8.0(–16.0) cm long, often hollow, twisted, sometimes flattened near the top, pubescent when young, gradually glabrescent to glabrous, with indumentum with long, white to brown hairs. Rachis as peduncle, but not flattened, (0–)2.5–7.0(–23.0) cm long, slightly pubescent–glabrescent, not tuberculate; flowers arising paired[15] or single; bracts 1 per flower, small, subulate, glabrescent; each group of flowers subtended by a larger bract, ovate, ca 3 mm long, acuminate at top, with several slender, parallelous length-nerves, sometimes few toothlets present, glabrescent; pedicels slender, up to ca 10 mm long, (slightly) pubescent to glabrescent, with two conspicuous bracteoles attached at the base of the calyx. Bracteoles ovate, ca 5–8 mm long, glabrescent, with many slender, dark coloured, parallelous length-nerves.

Calyx campanulate, slightly pubescent; tube ca 3 mm long; lobes subequal, triangular, ca 2–3 mm long, acute or acuminate at top.

Corolla: Standard with lower part directed forward, upper part erect above a deep sinus, hood-shaped, very broadly obovate, (10–)13(–15) × (11–)14(–16) mm, with longitudinal edges reflexed, with claw channel-shaped, with left and right two callosities (one large, one smaller), bi-auriculate, emarginate at top, glabrous, white (turning yellow-orange), light red-purple (turning yellow-white) or red-purple. Wings obovate, (14–)20(–25) × (9–)11(–14) mm, projecting forward, clawed, channel-shaped above the claw and upper part slightly fleshier, auriculate (slightly finely transversely striate near the auricle), rounded at top, papillulate, white (turning yellow or yellow-orange), light red-purple (turning yellow) or red-purple, adherent to the keel. Keel sharply upturned, ca 10 mm long, clawed, weakly auriculate, dorsally and ventrally split near the base, with left and right a weakly developed 'pocket', adherent to the wings, spiralled (forming less than 2 turns) at the apex, not connate at top, hiding the stigma, glabrous, white-green to yellow-green.

Androecium: Stamens diadelphous (9 + 1). Vexillary stamen free, ca 13 mm long, much shorter than the other stamens, compressed dorsally, tapering towards the top, appendiculate near the base, with appendix fitting between the callosities in the channeled claw of the standard, with upper part curving and spiralled. Staminal sheath slightly curved, sometimes auriculate and/or winged, ca 9 mm long, when on either side the first filament is released, irregularly followed by the other 7 stamens; free part of filaments winged towards the base, upturned and spiralled. Anthers ellipsoid, ca 1 mm long, dorsifixed, pale yellow.

Disk collar-shaped, ca 1 mm long, oblique, ribbed, repandous.

Gynoecium: Ovary sessile, laterally compressed, ca 5 mm long, finely velvety, beaked, as a rule with two brown lines near the dorsal suture (sometimes near the ventral suture as well), ca (4–)6(–9)-ovulate. Style upturned and spiralled, at base finely pubescent, with lower part flexible and apical part cartilaginous, adaxially with fine

15. The flowers of *P. vulgaris* are normally arranged in units of three ('triads') in such a way that two are lateral to a third. At flowering, only the two lateral flowers open, the median flower normally dropping off without opening. The two lateral members may open simultaneously, or, more commonly, one may open a day before the other (Ojehomon, 1966).

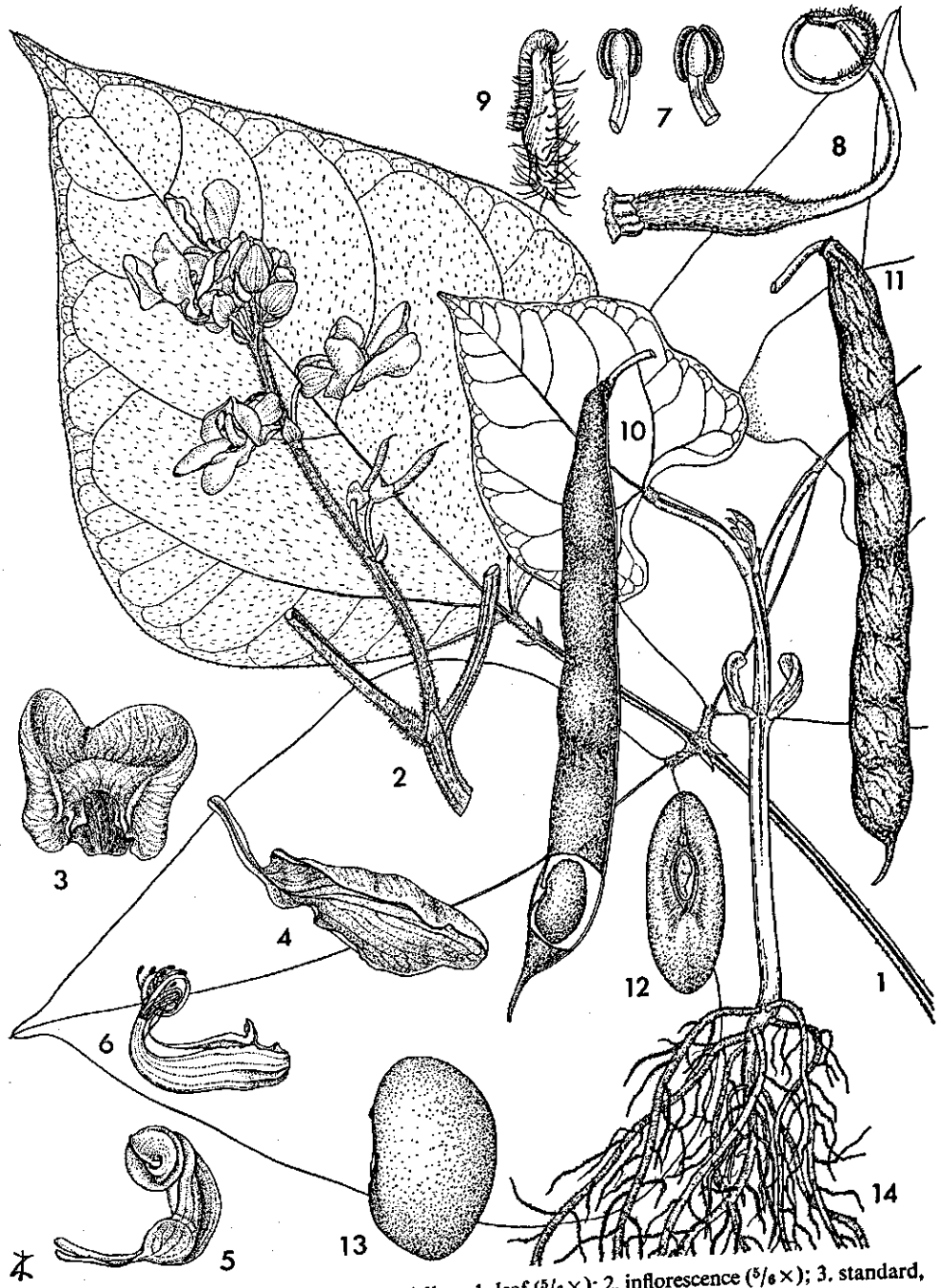


Fig. 18. *Phaseolus vulgaris* L. cv. Purple Bedelle. – 1. leaf (5/6 ×); 2. inflorescence (5/6 ×); 3. standard, adaxial view (2½ ×); 4. wing, adaxial view (2½ ×); 5. keel (2½ ×); 6. staminal sheath (2½ ×); 7. anthers (15 ×); 8. pistil (5 ×); 9. stigma (15 ×); 10. pod (5/6 ×); 11. pod (5/6 ×); 12. seed, with hilum (2½ ×); 13. seed, lateral view (2½ ×); 14. seedling (5/6 ×). – 1. WP 8463; 2. WP 8463 (including spirit mat.) and WP 8489 (including spirit mat.); 3–9. WP 8489 (spirit mat.); 10. WP 2205 (spirit mat., collected in Ethiopia); 11. WP 8464 (spirit mat., collected at Wageningen); 12–13. WP 5489A; 14. WP 8462 (spirit mat.).

patent hairs below the stigma. Stigma ellipsoid, directed adaxially, glandular, orange-yellow.

Pod linear, sometimes (slightly) curved, laterally compressed, (slightly) bulging over the seeds, (6.5–)9.0–18.0(–25.5) × 1.0–1.5(–2.0) cm, (prominently) beaked, with dorsal suture ridged and ± flat, with pod wall almost smooth to finely striate or rugulose, glabrescent, green, green-yellow or light brown, frequently with purple or violet spots or stripes, sometimes nearly purple, (2–)5–7(–9)-seeded; seeds separated by various amounts of intermediate (sept-like) tissue.

Seeds variable in size, shape and colour, as a rule oblong but also ellipsoid, globular or kidney-shaped, laterally compressed, (6–)8–17(–20) × (4–)5–7(–11) mm, white, purple, black, ochre, brown, white + black mosaic, brown + black mosaic, light coloured + purple mosaic, light coloured + red-purple mosaic, light coloured + brown mosaic, light coloured + orange mosaic, and grey-brown + very small light spots, usually glossy. Hilum oblong, sometimes elliptic, ca 2–3.5 mm long, ± central, covered by a layer of white detachable tissue, brownish, often surrounded by a darker coloured hilum ring, with a darker coloured, often conspicuous twin-bump situated near the hilum at the opposite side of the micropyle. Cotyledons whitish.

Seedling with epigeal germination. Root system well-developed with many laterals and adventitious roots. Hypo- and epicotyl (slightly) pubescent, green or purple; cotyledons oblong, sometimes sickle-shaped, lower surface grooved; petiole grooved above, (slightly) pubescent. First two leaves opposite, simple, (3.5–)5.0–7.5(–13.0) × (3.0–)3.5–5.5(–10.0) cm, deeply cordate at base, acuminate at top, slightly pubescent. Stipulae of the first two leaves as a rule connate; stipellae rarely present (1 or 2).

Note

At Wageningen 218 seed samples of *P. vulgaris* were sown and the resulting plants studied. Three habitus types were distinguishable.

(a) Climbing beans, ± 3 m high. Flowering started ca 70 days after sowing; some cultivars were as late as 160 days, whereas some (less than 1%) did not flower at all. Pods matured 120–170 days after sowing; some cultivars did not fruit at all, or only very late in the season. Seeds from which it was known that they belong to climbing cultivars under Ethiopian circumstances always produced plants with a climbing habit. As a rule the pods are longer and wider than those of the bushy cultivars. Cultivars which gave rise only to climbing plants are White Soddo, White Kolito, Pretty Dila, Purple Alemaya, Jima Mosaic, Agaro Mosaic, Kurfachelli Mosaic, Langano Mosaic, Giant Ebba and Giant Eyob. Some cultivars gave rise to bushy and/or vining plant types as well (see under (b) and (c)).

(b) Bush beans, ± 50–70 cm high. Flowering started 50–70 days after sowing; some cultivars were as late as 80 days. Pods matured within 120 days after sowing. As a rule the pods are shorter and less wide than the true climbing beans. Within this group White Harar once showed a number of vining plants; White Asella, Gergertu Mosaic, Hirna Resort, Gergertu Temptation and Charming Chercher produced climbing as well as bushy plant types. Purple Gelemso, Nazret Mosaic, Glossy Wonji, Asella Ebony and nearly always also White Harar gave bushy plant types.

(c) Vining beans, ± 1–1.5 m high. Flowering started ca 70–80 days after sowing; few cultivars flowered later than 100 days after sowing, or did not flower at all. Pods matured 120–170 days after sowing; few did not fruit at all. Within this group Dutch Comfort yielded only vining plants, Dawit's Despair showed a climbing plant habit as well, whereas Purple Awasa, Purple Bedelle, Bedessa

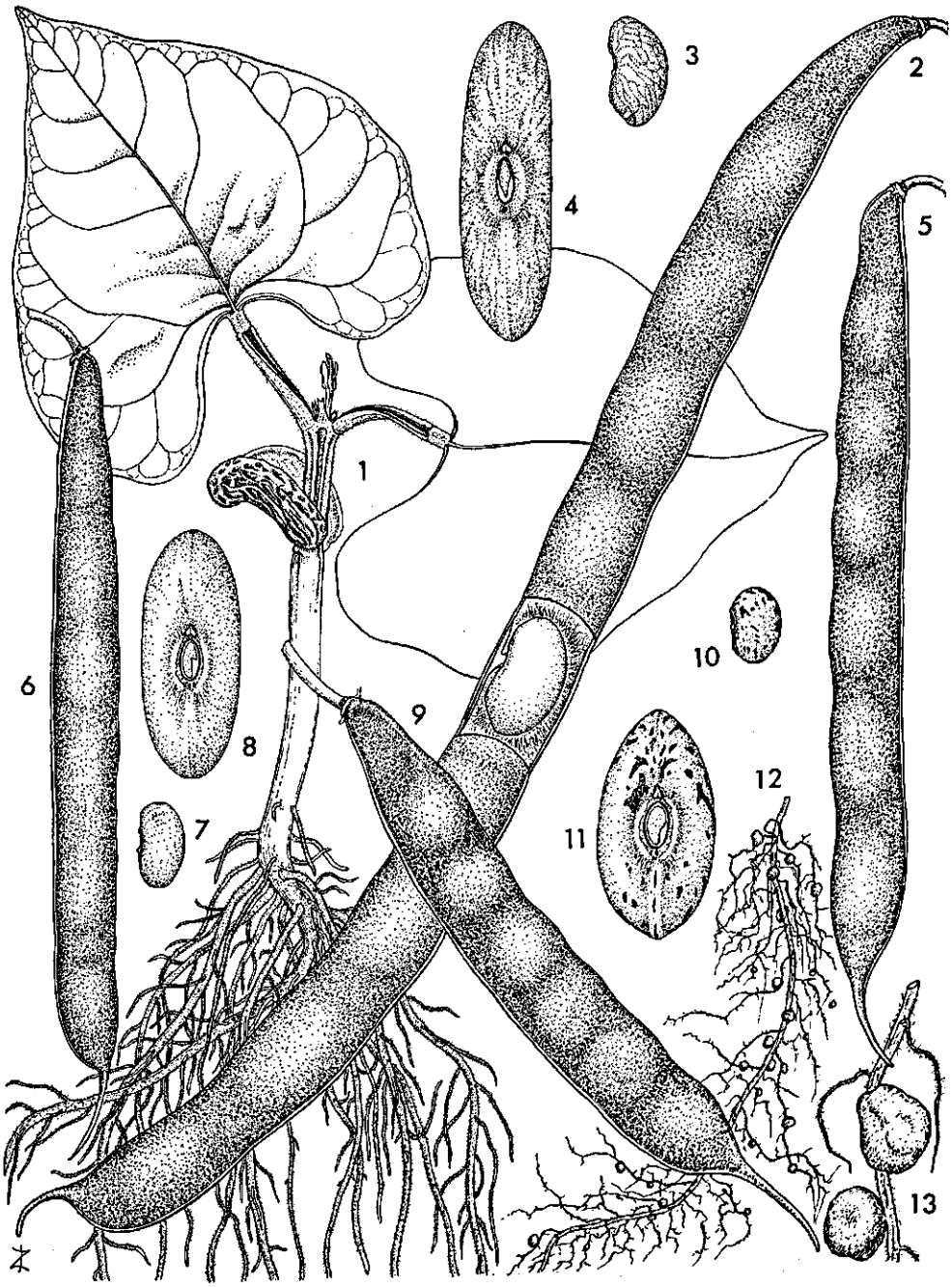


Fig. 19. *Phaseolus vulgaris* L. cv. White Kolito. – 1. seedling (5/6×); 2. pod (5/6×); 3. seed, lateral view (5/6×); 4. seed, with hilum (2½×). Cv. Hirna Resort. – 5. pod (5/6×); 6. pod (5/6×); 7. seed, lateral view (5/6×); 8. seed, with hilum (2½×). Cv. Pearly Nazret. – 9. pod (5/6×); 10. seed, lateral view (5/6×); 11. seed, with hilum (2½×). Unknown cv. – 12. nodules (5/6×); 13. nodules (5×). – 1. WP 8469 (spirit mat.); 2. WP 8471 (spirit mat.); 3–4. WP 8471; 5. WP 8034 (spirit mat., collected at Wageningen); 6. WP 2188 (spirit mat., collected in Ethiopia); 7–8. WP 2188; 9. WP 8384 (spirit mat.); 10–11. WP 3518C; 12–13. WP 525.

Mosaic, Wonji Mosaic, Gelemso Mosaic, Pearly Nazret, Brown Buditi, Hirna Beauty and Black Konso produced climbing and bushy plant types as well.

From these results it is apparent that for certain cultivars differences in photoperiodic response are manifest within the same cultivar which do not become manifest under Ethiopian circumstances. For example the well-known cultivar Purple Bedelle is found as a rule, at least in the Chercher region, in the bushy form, whereas at Wageningen also vining and climbing specimens developed. However, in the Chercher area some bean types were encountered in the sorghum/maize fields which showed a slight tendency to vining.

Taxonomic notes

(1) In LINN one sheet with *Phaseolus vulgaris* is present (899.1) bearing the reference, by Linnaeus, to Sp. Pl. ed. 1 and the annotation HU (Hortus Upsaliensis). Verdcourt (1971) designated specimen 899.1 as the lectotype of *Phaseolus vulgaris* L., a choice which has been followed here.

(2) Pre-Linnaean botanists distinguished between climbing beans and bush beans. Linnaeus at first listed in Sp. Pl. ed. 1 only *P. vulgaris:* '*Phaseolus* scandentes, caule volubili, floribus racemosis geminis, bracteis calyce majoribus, leguminibus pendulis'. In Cent. Pl. 1: p. 23 (1755) and Am. Acad. 4: p. 284 (1759) a second common bean is described under the designation *P. nanus:* '*Phaseolus* (nanus) caule erectiusculo laevi, bracteis calyce majoribus, leguminibus pendulis compressis rugosis'. Both species are maintained in Sp. Pl. ed. 2 (1763).

The distinction between the true climbing and the true bush types is considered to be due to a single pair of characteristics; the indeterminate growth of the climbing beans being dominant over the determinate habit of the bush beans. Differences in seed size, shape and colour, leaf size and shape, and flower colour are not conclusive for either type (climbing or bushy) when applied with the expectation of establishing separate taxa (Hedrick et al., 1931). Thus, the difference in growth habit, important as it may be horticulturally, cannot be used as a segregating characteristic in establishing separate species, since also semi-climbing or slightly climbing types exist (Von Martens, 1869). The same is true with regard to differences in pod and seed characteristics.

Savi (1822, 1825) distinguished, within the *P. vulgaris* L. - *P. nanus* L. complex, the following species based on seed differences: *P. vulgaris* Savi ('seminibus ovatis subcompressis'), *P. romanus* ('sem. compressis'), *P. oblongus* ('sem. teretiusculis latitudine duplo longioribus'), *P. tumidus* ('sem. ovato-turgidis, ventre tumido'), *P. sphaericus* ('sem. subrotundis'), *P. gonospermus* ('sem. compressis irregulariter angulatis'), *P. saponaceus* ('sem. albis, ventre maculatis'), and *P. haematocarpus* ('legumine immaturo maculis sanguineis notato, sem. variegatis'). He came to 55 different types of beans.

De Candolle (Prodr. 2: p. 392–393 (1825)) took over Savi's species except *P. romanus* Savi which he gave the name *P. compressus.*

Fingerhuth (1835) divided the common bean complex in 3 groups: group 1 ('sem. compressis') with *P. compressus* DC., *P. vulgaris* Savi, *P. amoenus* F., *P. zebra* F., *P. gonospermus* Savi and *P. triangulus* F.; group 2 ('sem. oblongis') with *P. oblongus*

Savi, *P. saponaceus* Savi, *P. praecox* F. and *P. tumidus* Savi; and group 3 ('sem. subrotundis') with *P. sphaericus* Savi, *P. ovalispermus* F. and *P. lupinoides* F. Totally 99 taxa.

Von Martens (1860, 1869) distinguished the following species: *P. vulgaris* Savi (with 34 types), *P. compressus* (with 18 types), *P. gonospermus* (with 9 types), *P. carinatus* (with 2 types), *P. elongatus* (with 22 types), *P. ellipticus* (with 17 types) and *P. sphaericus* (with 18 types). In total 120 types. Von Martens, as Savi, distinguished taxa with monocoloured testa and with striped, blotched or marbled testa within each species.

Alefeld (1866) considered that all taxa belong to *P. vulgaris* L. He differentiated between the following groups of varieties: *subcompressus* (*P. vulgaris* Savi) with 34 types, *compressus* (*P. compressus* DC.) with 19 types, *gonospermus* (*P. gonospermus* Savi) with 9 types, *carinatus* (*P. carinatus* Mart.) with 2 types, *elongatus* (*P. oblongus* Savi) with 22 types, *ellipticus* (*P. ellipticus* Mart.) with 18 types, and *sphaericus* (*P. sphaericus* Savi) with 20 types. Totally 124 taxa.

Taubert (1894) comes to the following division within *P. vulgaris* L.: *communis* ('gemeine Stangen-, Lauf- oder Steigbohne'); *compressus* ('Speckbohne'); *ellipticus* ('Eierbohne'), white ('Kugel- oder Perlbohne') or black ('Negerbohne'); *sphaericus* ('Kugelbohne'); and *nanus* ('Zwerg-, Krup-, Busch-, Zucker- oder Frühbohne'). He referred to more than 70 forms of common beans.

Ascherson & Graebner (1906–1910) distinguished within *P. vulgaris* L. the following taxa: seeds oblong–kidney-shaped, with (a) *communis* ('Stangenbohne'), *compressus* ('Speckbohne'), *gonospermus* ('Eckbohne') and (b) *nanus* ('Krupbohne, Buschbohne'); seeds round-ellipsoid, with (a) *sphaericus* ('Kugelbohne, Perlbohne') and (b) *ellipticus* ('Adlerbohne').

Gams, in: Hegi (1924) came to the following taxa within *P. vulgaris* L.: var. *subcompressus* Alef. (*P. vulgaris Savi*), 'gemeine Gartenbohne'; var. *compressus* (DC.) Alef. (*P. romanus* Savi), 'Schwertbohne, Speckbohne'; var. *gonospermus* (Savi) Alef., 'Eckbohne'; var. *carinatus* (Mart.) Alef., 'Kielbohne'; var. *oblongus* (Savi) Alef., 'Dattelbohne, Langbohne'; var. *ellipticus* (Mart.) Alef., 'Eierbohne'; and var. *sphaericus* (Savi) Alef., 'Kugelbohne'. More than 500 forms of the common bean are known.

Van Eseltine, in: Hedrick (1931) placed the bush bean in forma *nanus* (L.) van Eseltine of *P. vulgaris* L. Supposedly the climbing beans are placed in forma *vulgaris*, but strangely Van Eseltine omitted any indication as to the taxon in which the climbing beans are to be placed.

Mansfeld (1959) distinguishes within *P. vulgaris* L. ssp. *aborigineus* (Burkart) Mansf. embracing wild taxa of which the seeds are collected by the people in South America, and ssp. *vulgaris* which is *P. vulgaris* L. sensu stricto. Within the latter taxon two varieties are discerned: var. *vulgaris* (syn. *P. vulgaris* var. *communis* Ascherson, in: Fl. Prov. Brandenb.: p. 170 (1864)), the climbing beans; and var. *nanus* (L.) Ascherson (l.c.), the bush beans.

(3) Gradually it was realized that the application of traditional taxonomy in delimiting the different taxa of *P. vulgaris* L. was unsatisfactory, since the variation

within the common bean can be attributed to the existence of several hundreds of cultivars. This variation cannot be met by the creation of subspecies, varieties and formae within *P. vulgaris*. Irish (1901) constructed a key to the cultivars of the common beans based on the following characteristics in order of their importance as segregating characteristics: shape of seeds and pods, followed by seed colour and seed size, plant growth habit, and size of the pods. Tracy (1907) attempted for the first time a key to the cultivars of the common bean that contained several plant characteristics other than those of seed and pod. Hedrick et al. (1931) for the U.S.A. differentiated between the following groups of bean cultivars.

(a) Garden beans. (1) Climbing cultivars with green or wax pods; pods may be picked when young and free from fibre and parchment, or allowed to ripen until the young seeds become swollen but before the pods become dried. Other cultivars, especially those with white seeds, are suitable for use as a dry bean when harvested after the pods and seeds are fully mature. (2) Bush cultivars with green or wax pods; they are grown for the pods which are cooked when young.

(b) Horticultural or shell beans with climbing or bush growth habit. They are characterized by smooth, dark coloured leaves; by pods which, in the green shell stage, are abundantly splashed with carmine or red and which are much swollen over the seeds; and by large tumid seeds, with white or light buff undercoloured and more or less splashed and streaked with dark red. As a shelled bean, both green as well as dry seeds are used.

(c) Field beans. These bush cultivars produce dry beans; for the greater part the seeds are solid coloured white, red, brown, yellow or black, but also mottled types exist. On the markets the white-seeded cultivars are divided into pea, medium, marrow and kidney beans, based on size and shape of the seeds.

Generally beans are classified according to their use (see Irish, 1901; Purseglove, 1968, and others) as follows.

(a) Snap or string beans, grown for the pods harvested before fully grown and while still slender, with seeds small. Flat or oval-podded cvs are preferred for the fresh market; round-podded cvs with white seeds are preferred for canning; flat-podded cvs are used for slicing or French beans. The following types of snap beans are recognized: green-podded bush cvs, wax or yellow-podded bush cvs, green-podded climbing cvs, and wax or yellow-podded climbing cultivars.

(b) Green-shell beans, used in the green-shelled condition. Bush as well as climbing cultivars exist. These are of comparatively little importance.

(c) Dry-shell or field beans, grown for the dry, ripe seeds. Extensively grown in South America and tropical Africa, where many cultivars exist showing a great variation in seed coat colour. The following types of field beans are distinguishable: medium field beans with seeds 1–1.2 cm long, pea or navy beans with seeds 8 mm long or less, red kidney beans with seeds 1.5 cm long or more, and marrow beans with seeds 1–1.5 cm long.

(4) The following pod types were distinguished in the specimens raised at Wageningen.

(a) Pods 17 cm or longer, 1–1.5 cm wide; seeds as a rule oblong, large, ca 1.5–2 cm long. Most cultivars are climbers (White Kolito, White Soddo, Giant Ebba, Giant Eyob, Jima Mosaic and Agaro Mosaic), except Purple Gelemso, Asella Ebony and Nazret Mosaic.
(b) Pods less than 17 cm long, ca 1 cm wide; seeds as a rule oblong, sometimes globular like the cultivars Pearly Nazret and Pearly Wonji, medium (1.0–1.5 cm) or small (less than 1.0 cm). The cultivars are bushy and/or vining and/or climbing as well (the cultivars White Hirna, Kurfachelli Mosaic, Dawit's Despair and Dutch Comfort did not produce mature pods and are not taken into consideration).

Cultivars from which pods were available raised both in Ethiopia and Wageningen generally showed a higher number of seeds per pod in specimens grown at Wageningen. Possibly this is due to the great care with which the plants were cultivated (manuring, etc.). In addition, the length of the pod exceeded that of the available Ethiopian-raised material. It is not unlikely that this is the case with all cultivars.

(5) F_1-seeds from Wageningen plants raised from seeds collected in Ethiopia were remarkably similar in shape and colour to the original P-seeds. Based on 33 seed types the following cultivars can be recognized (in establishing colours sometimes the colour chart of the Royal Horicultural Society has been used).

A. Monocoloured

1. White
(1) Seeds oblong, large, sometimes glossy: cv. White Soddo (WP 2975A, WP 8154–WP 8156). Flowers white. Infrequent (Hararge, Sidamo (Wollamo)).
(2) Seeds oblong, sometimes kidney-shaped, large–medium: cv. White Kolito (WP 3242, WP 8326–WP 8327). Flowers white. Infrequent (e.g. Hararge, Shoa, S. W. Ethiopia).
(3) Seeds ellipsoid, medium, slightly glossy: cv. White Hirna (WP 4006i). Flowers white? Only once found.
(4) Seeds globular–ellipsoid, small: cv. White Asella (WP 3073D, WP 8254–WP 8256). Flowers white. Infrequent (e.g. Hararge, Gamu Gofa (Konso)).
(5) Seeds oblong, sometimes kidney-shaped, small: cv. White Harar (WP 69, WP 8008–WP 8010). Flowers white. Frequent, especially in Hararge, but in other regions as well.

2. Purple
(6) Seeds oblong, large, greyed-purple (187A), glossy: cv. Purple Gelemso (WP 2589C, WP 8100–WP 8101). Flowers light red-purple. Infrequent (e.g. Hararge).
(7) Seeds oblong, small–medium, glossy, greyed-purple (187A): cv. Purple Awasa (WP 2845E, WP 8145–WP8147). Flowers red-purple; pods purplish. Infrequent (e.g. Hararge).
(8) Seeds oblong to globular, small, glossy, greyed-purple (187B): cv. Purple Bedelle (WP 5489A, WP 8462–WP 8464). Flowers as a rule light red-purple; pods purplish. Frequent (e.g. Hararge, Shoa, S.W. Ethiopia).
(9) Seeds oblong, small, glossy, purple (79A): cv. Purple Alemaya (WP 2171B, WP 6188, WP 7998–WP 7999). Flowers red-purple; pods purplish. Only once found.

3. Black
(10) Seeds oblong, large, glossy: cv. Asella Ebony (WP 3073F, WP 8257–WP 8259). Flowers red-purple. Infrequent (e.g. Hararge, Sidamo, Kefa).
(11) Seeds oblong, sometimes conspicuously laterally compressed, medium–small, sometimes glossy: cv. Black Konso (WP 3223A, WP 8300–WP 8302). Flowers red-purple; pods purplish. Frequent (e.g. Hararge, Shoa, Sidamo, Gamu Gofa (Konso), Kefa).

4. Ochre

(12) Seeds globular-ellipsoid, medium–small, greyed-orange (163C) with a brown hilum ring and dark brown twin-bump: cv. Pearly Wonji (WP 3066B, WP 8230–WP 8232). Flowers light red-violet? Only once found.

5. Brown

(13) Seeds oblong, rectangular, large, greyed-orange (164A) with a dark brown hilum ring and twin-bump: cv. Giant Ebba (WP 5555, WP 8497–WP 8499). Flowers white; sometimes found in Jima area (Kefa).

(14) Seeds oblong, rounded at both ends, large, rather glossy, greyed-orange (173C–175C) with dark brown hilum ring and twin-bump: cv. Giant Eyob (WP 4006K, WP 8395–WP 8397). Flowers as a rule red-purple; pods purplish. Infrequent (e.g. Hararge, S.W. Ethiopia).

(15) Seeds oblong, large–medium, glossy, brown (200A–B): cv. Gergertu Temptation (WP 2545D, WP 8051–WP 8053). Flowers red-purple; pods purplish. Infrequent (e.g. Hararge).

(16) Seeds oblong to kidney-shaped, large, glossy, greyed-orange (175B–C) to greyed-red (182B): cv. Pretty Dila (WP 2844, WP 6684, WP 7179, WP 8143). Flowers red-purple. Only a few times found (Sidamo).

(17) Seeds oblong, medium, glossy, greyed-orange (164A) with dark brown hilum ring and twin-bump: cv. Hirna Resort (WP 4007i, WP 8407–WP 8409). Flowers as a rule red-purple; pods as a rule not purplish. Frequent (e.g. Hararge, S.W. Ethiopia).

(18) Seeds oblong to ellipsoid, medium–small, sometimes glossy, greyed-orange (166A) to brown (200D): cv. Hirna Beauty (WP 3019H, WP 8207–WP 8209). Flowers as a rule red-purple; pods purplish. Frequent (e.g. Hararge).

(19) Seeds oblong, small–medium, slightly glossy, greyed-orange (174D-174A): cv. Brown Buditi (WP 2553H, WP 8072–WP 8074). Flowers red-purple; pods as a rule not purplish. Not frequent (e.g. Hararge).

(20) Seeds oblong to ellipsoid, small, glossy, greyed-orange (172A) with dark brown hilum ring and twin-bump: cv. Glossy Wonji (WP 3069J, WP 8245–WP 8247). Flowers white. Only once found.

(21) Seeds oblong, small, greyed-orange (167A), with dark brown hilum ring and twin-bump: cv. Dutch Comfort (WP 3003G, WP 6941, WP 6971, WP 7321). Flowers white. Only a few times found (e.g. around Nazret (Shoa)).

(22) Seeds oblong, medium–small, glossy, grey-dark brown: cv. Dawit's Despair (WP 4981A). Flowers red-purple. Only a few times found (e.g. Hararge, north Ethiopia).

B. Variegated

6. White + black spots

(23) Seeds oblong, large, glossy, spickled with black spots, hilum surrounded by black: cv. Nazret Mosaic (WP 3000D, WP 8168–WP 8170). Flowers red-purple. Only once found.

7. Brown + black mosaic

(24) Seeds oblong, sometimes kidney-shaped, large, frequently glossy, greyed-orange (172A)–orange (29C) with black mosaic and stripes, with brown hilum ring and black twin-bump: cv. Jima Mosaic (WP 5562, WP 8534–WP 8536). Flowers as a rule red-purple; pods purplish. Few times found in Jima region (Kefa).

(25) Seeds oblong and sometimes conspicuously laterally compressed, or ellipsoid–globular, medium–small, infrequently glossy, greyed-orange (175C)–orange-white (159A) with mosaic mainly consisting of prominent lateral black lines, with brown hilum ring and twin-bump: cv. Bedessa Mosaic (WP 5560E, WP 8522–WP 8624). Flowers red-purple; pods purplish. Frequent (e.g. Hararge, S. W. Ethiopia, north Ethiopia).

(26) Seeds oblong, small, greyed-orange (174D)–orange-white (159A) with mosaic mainly consisting of irregular black spots, with brown hilum ring and twin-bump: cv. Langano Mosaic (WP 2592E, WP 8119–WP 8121). Flowers red-purple, pods purplish. Few times found (e.g. Sidamo).

8. Light coloured + purple mosaic
(27) Seeds oblong, large–medium, glossy, greyed-orange (173C)–orange-white (159A) with purple mosaic (sometimes very dominant), hilum ring brown and twin-bump dark brown or purple: cv. Agaro Mosaic (WP 2574E, WP 8087–WP 8089). Flowers red-purple, pods purplish. Only a few times found (e.g. Hararge).

9. Light coloured + red-purple mosaic
(28) Seeds oblong, sometimes slightly kidney-shaped, large–medium, glossy, greyed-red (179B)–greyed-orange (173C) with red-purple mosaic (sometimes very dominant), hilum ring dark brown and twin-bump dark brown or red-purple: cv. Gergertu Mosaic (WP 5511A, WP 8472–WP 8474). Flowers as a rule red-purple; pods purplish. Frequently found (e.g. Hararge, Shoa, Sidamo, Kefa).
(29) Seeds ellipsoid–globular, medium, slightly glossy, greyed-orange (179B) with red-purple mosaic, hilum ring and twin-bump dark brown: cv. Pearly Nazret (WP 3005i, WP 7233, WP 7326, WP 6987). Flowers as a rule light red-purple; pods purplish. Frequent (e.g. Hararge, Shoa).

10. Light coloured + brown mosaic
(30) Seeds oblong, medium, slightly glossy, greyed-orange (173C-D) with brown mosaic (sometimes dominant), hilum ring brown, twin-bump dark brown: cv. Wonji Mosaic (WP 3069H, WP 8242–WP 8244). Flowers white. Infrequent (e.g. Shoa, Sidamo).
(31) Seeds oblong, medium, glossy, greyed-orange (±173D) with dark brown mosaic (rather dominant), hilum ring and twin-bump dark brown: cv. Gelemso Mosaic (WP 2575D, WP 8095–WP 8097). Flowers as a rule light red-purple; pods purplish. Infrequent (Hararge).

11. Light coloured + orange mosaic
(32) Seeds oblong, small, orange-white (159A)–greyed-orange (166D) with yellow-orange (22A)–greyed-orange (167C) mosaic mainly consisting of prominent lateral lines, hilum ring ± orange or dark brown, twin-bump light coloured or dark brown: cv. Kurfachelli Mosaic (WP 2480, WP 6314–WP 6315). Only once found (Hararge).

12. Grey-dark brown + very small lighter coloured spots
(33) Seeds oblong, medium, glossy: cv. Charming Chercher (WP 2590C). Flowers red-purple; pods as a rule not purplish. Infrequent (e.g. Hararge).

(6) The following differences were found between plants raised at Wageningen and in Ethiopia.

	Wageningen	Ethiopia
petiole	(6.5–) 10.0–15.0 (–32.5)	(6.0–) 10.0–15.0 (–17.0)
rachis	(2.0–) 2.5– 3.5 (– 6.0)	(1.5–) 2.5– 3.0 (– 4.0)
leaflet: length	(6.5–) 8.0–14.0 (–20.5)	(5.5–) 7.5– 9.0 (–10.0)
width	(4.5–) 6.5–10.0 (–15.5)	(4.5–) 5.5– 7.0 (– 8.0)
peduncle	(0 –) 3.0– 8.0 (–16.0)	(1.0–) 3.0– 7.0 (– 9.5)
rachis	(0 –) 2.5– 7.0 (–23.0)	(0 –) 3.0– 4.5 (– 8.0)
seedling, 1st leaf: length	4.0–13.0	3.5– 8.0
width	3.0–10.0	3.0– 6.5

(7) The description is based on the following specimens.

Tigre	Axum market: WP 4981A–WP 4981C.
Wollo	Bati market: WP 4015A–WP 4015C; Haik market: Sl 1134.
Shoa	Addis Abeba market: WP 3029; Robi market: Sl 1156, Sl 1161; Langano market: WP 2592A–WP 2592H, WP 2593A–WP 2593D, WP 2594A–WP 2594i; Shashamane market: WP 2595A–WP 2595E, WP 2596A–WP 2596F; Kolito market: WP 2860A–WP 2860F, WP 3242, WP 3243A–WP 3243F; Nazret market: WP 2998A–WP 2998F, WP 2999A–WP 2999F,

	WP 3000A–WP 3000K, WP 3001A–WP 3001D, WP 3002A–WP 3002E, WP 3003A–WP 3003H, WP 3004A–WP 3004E, WP 3005A–WP 3005N; Wonji market: WP 3066A–WP 3066B, WP 3067A–WP 3067E, WP 3068A–WP 3068B, WP 3068D–WP 3068E, WP 3069A–WP 3069L; 5 km past Nazret on Asella road: WP 1506.
Wellega	Nekemte market: WP 5548A–5548C; Shankalla market on Gimbi road near Didessa river: WP 3383; Gimbi market: WP 3385B.
Illubabor	Bedelle market: WP 5489A–WP 5489B, WP 5489D–WP 5489E.
Kefa	Assendabo market: WP 3364A–WP 3364D, WP 3365A–WP 3365C, WP 3366A–WP 3366G, WP 3367A–WP 3367C; 33 km past Jima on Assendabo road: Taddesse Ebba 584; Jima market: WP 3361A–WP 3361K, WP 5509, WP 5511A–WP 5511B, WP 5512A–WP 5512C, Sl 125, Sl 135; 20 km past Jima on Suntu road, in garden: WP 3266; Agaro market: WP 3354A–WP 3354C, WP 5492, WP 5516A–WP 5516C, WP 5516E–WP 5516H; 14 km past Jima on Bonga road, in garden: WP 5495, WP 5507; 52 km past Jima on Bonga road, in garden: WP 5526A–WP 5526B; Shebe market: WP 3352A–WP 3352D, WP 3353; Bonga market: WP 3341A–WP 3341F, WP 5538A–WP 5538C; Woshi market: WP 8567, Maji market: J. J. de Wilde 8568.
Gamu Gofa	Gidole market: WP 3229, WP 3230A–WP 3230B, WP 3230D; Giarso market: WP 3223A, WP 3223C–WP 3223D, WP 3225B, WP 3226A–WP 3226B, WP 3227A–WP 3227C.
Sidamo	Awasa market: WP 2716A–WP 2716M, WP 2845A–WP 2845K; 29 km past cement factory on Wondo road, in fence: WP 2639; Yirga Alem market: WP 3144A–WP 3144E, WP 3144H–WP 3144J, WP 3144L, WP 4056A–WP 4056H; Wondo market: WP 2812A–WP 2812B; 1 km past Wondo on Agere Selam road, in garden: WP 2663; 3 km past Kebre Mengist on Agere Selam road, in garden: WP 2717A–WP 2717C, WP 2717E, WP 2718, WP 2719; Teferi K'ele market: WP 4061A, WP 4061C–WP 4061F, WP 4061H, WP 4062A–WP 4062F; 16 km past Dila on Wondo road, in garden: WP 2843–WP 2844; 28 km past Dila on Yirga Chaffe road, in garden: WP 3151; Buditi market: WP 2872A–WP 2872E; Soddo market: WP 2945A–WP 2945D, WP 2946A–WP 2946E; market, 20 km south of Soddo: WP 3238A–WP 3238F; 4 km from junction Soddo road to Abella, in field: WP 2975A–WP 2975C.
Arussi	Asella market: WP 3072A–WP 3072B, WP 3073A–WP 3073B, WP 3073D–WP 3073F; Sire market: Sl 158.
Hararge	Assebot market: Sl 694; Mieso market: WP 3517A–WP 3517F; Asbe Teferi market: WP 3518A–WP 3518K, Sl 471, Sl 472, Sl 473; Bedessa market: WP 3176A–WP 3176F, Sl 662, Sl 663; Karra market: Sl 578–Sl 580; K'uni market: Sl 530–Sl 533; Moulou market: Sl 439, Sl 441; Gelemso market: WP 2573A–WP 2573G, WP 2574A–WP 2574G, WP 2574i, WP 2575A–WP 2575E, WP 2575G, WP 2589B–WP 2589H, WP 2590A–WP 2590F, Sl 615, Sl 620; Waichu market: Sl 513–Sl 514; market, 28 km past Asbe Teferi on Hirna road: WP 3017A–WP 3017D, WP 3019A–WP 3019M; Hirna market: WP 4006A–WP 4006O, WP 4007A–WP 4007D, WP 4007F–WP 4007L; Ch'elenko market: Sl 247; 25 km past Langhe on Deder road, in field: WP 2515–WP 2516; Deder market: Sl 387, Sl 388; 17 km past Harawacha on Gergertu track, in fence: WP 2537–WP 2538; Gergertu market: WP 2545A–WP 2545J; K'obo market: WP 3504A–WP 3504H; Kulubi market: WP 2497–WP 2508 (coll. Taddesse Ebba); 4 km past Langhe on

Kulibi road, in field: WP 2375–WP 2378; 11 km past Langhe on track to Bedeno, in field: WP 2379; Wotter market: Sl 199; Bedeno market: Sl 322; 66 km past Bedeno on Kurfachelli track, in field: WP 2480–WP 2482; Langhe market: Sl 292; Dire Dawa market: WP 191; Alemaya market: WP 2A–WP 2D, WP 19A–WP 19H, WP 20, WP 1185A–WP 1185C, WP 1185E, WP 3032A–WP 3032Q, WP 3032S–WP 3032U, Sl 231; garden Alemaya: WP 204–WP 207, WP 229–WP 236, WP 279, WP 285–WP 293, WP 300, WP 302, WP 305, WP 316, WP 320–WP 325, WP 333–WP 337, WP 723, WP 732, WP 751, WP 1052, WP 1053, WP 1067, WP 1072–WP 1074, WP 1190, WP 1196, WP 1776, WP 1787–WP 1791, WP 1809–WP 1818, WP 1822–WP 1824, WP 2171, WP 2171A–WP 2171C, WP 2172, WP 2172A–WP 2172B, WP 2173, WP 2185–WP 2191, WP 2203, WP 2203A–WP 2203B, WP 2205–WP 2209, WP 2483–WP 2494, WP 3013; College of Agriculture: WP 2510, WP 2512A–WP 2512C, WP 2513, WP 2514A–WP 2514B, WP 5555–WP 5557 (coll. Taddesse Ebba), WP 5562 (coll. Melak H. Mengesha, from Kefa); near College entrance on Kombolcha road, in garden: WP 383, WP 392, WP 393; ca 2 km from College entrance on Kombolcha road, in field: WP 444, WP 450, WP 453, WP 456, WP 461, WP 462, WP 525, WP 2336–WP 2341, WP 2343–WP 2345; ca 4 km from College entrance on Kombolcha road, in field: WP 668; Harar market: WP 69, WP 84A–WP 84L, WP 86A, WP 86E–WP 86G, WP 88A–WP 88B, WP 101A, WP 102B, WP 103A–WP 103F, WP 103H, WP 104B, WP 105A–WP 105F, WP 2551A–WP 2551C, WP 2551F, WP 2552A–WP 2552H, WP 2553A–WP 2553F, WP 2553H, WP 2555A–WP 2555D, WP 3188E, WP 3189G–WP 3189S, WP 3190A–WP 3190i, WP 3492A–WP 3492C, WP 4039A–WP 4039B, WP 4039G–WP 4039i, WP 4039L–WP 4039O, WP 4039Q–WP 4039S, WP 5559A–WP 5559G, WP 5560A–WP 5560i, WP 5561A–WP 5561D; 8 km past Harar on Jijiga road, in field: WP 2360; Feddis market: Sl 192, Sl 193; Jijiga market: Sl 344.

Grown at Wageningen WP 5568–WP 5575, WP 5658–WP 5675, WP 5843–WP 5846, WP 5876–WP 5892, WP 5899–WP 5900, WP 5907–WP 5914, WP 5919–WP 5923, WP 5954, WP 5958–WP 5969, WP 5971–WP 5974, WP 5977–WP 5989, WP 6135–WP 6137, WP 6187–WP 6198, WP 6222–WP 6236, WP 6261–WP 6262, WP 6265–WP 6272, WP 6277–WP 6292, WP 6297–WP 6298, WP 6303–WP 6312, WP 6314–WP 6357, WP 6360–WP 6364, WP 6369–WP 6400, WP 6408–WP 6478, WP 6537–WP 6538, WP 6567–WP 6607, WP 6629–WP 6632, WP 6684–WP 6704, WP 6733–WP 6743, WP 6758–WP 6764, WP 6770–WP 6788, WP 6812–WP 6818, WP 6891–WP 6996, WP 7004–WP 7006, WP 7010–WP 7019, WP 7023–WP 7049, WP 7105–WP 7127, WP 7129–WP 7134, WP 7159–WP 7169, WP 7171–WP 7187, WP 7189–WP 7269, WP 7271–WP 7342, WP 7981–WP 8536.

Ecology

Phaseolus vulgaris is not adapted to the humid tropics, it grows well in areas with medium rainfall from the tropics to the temperate regions. It is killed by night frost and sensitive to very high temperatures. Dry weather during the critical flowering and setting period is detrimental. Excessive rains cause shedding of flowers and increase the incidence of diseases. In very hot weather the plants drop their blossoms and

pods (Choudhury, in: Kachroo, 1970). Dry weather is required for harvesting dry-shell beans. Common bean can be grown on practically all soil types from light sands to heavy clays and also on peat soils, but not on very acid soils. It is sensitive to high concentrations of aluminium, manganese and boron (Purseglove, 1968), but no information is available on the harmfull concentrations of these elements. It cannot stand water-logging (Stanton et al., 1966). In testing for photoperiod in the U.S.A. all bush cultivars were found to be day-neutral, half those of the pole type were short-day plants and half were day-neutral (Purseglove, 1968).

Husbandry

In tropical Africa common bean is seldom grown as a separate crop but generally interplanted (usually as a mixture of cultivars) with maize, sweet potato, cotton and coffee (Purseglove, 1968). The commonest types are white-seeded or dark red-seeded cultivars such as 'Canadian Wonder'[16]. The latter is one of the most widespread and occurs throughout Africa, because it is resistant to a wide spectrum of diseases. In contrast to many parts of Africa, the coloured types are preferred by many Kenyan people (Stanton et al., 1966). Normally, the bush cultivars are grown as a field crop, both for external trade (such as in Malawi), and for internal trade (such as in Uganda, Kenya). They may also be grown as a sole crop under market-gardening conditions. As a field crop they are sown either at the beginning of the rains or under irrigation (Stanton et al., 1966). In the plains of India, beans are sown twice a year, in July to September and in January–February. In the hilly regions the crop is sown during the period March to begin May, when the danger of night frost has passed and the soil has sufficiently warmed up (Choudhury, in: Kachroo, 1970).

Unlike the cowpea common beans are not always interplanted, but may be cultivated as a single crop between two successive cereals such as maize and wheat. Interplanting is, however, practised in Rhodesia, in Kenya with cotton (2 rows bean/2 rows cotton) or on a very large scale with maize. Climbing cultivars are normally a market-garden crop (under irrigation) or a compound crop, where they are grown up the compound fence, or around trees. While bush cultivars are normally grown for seed, types suitable for snap beans are common among the climbers (Stanton et al., 1966).

In pure stands the bush cultivars yield highest at a spacing of 30–45 cm between the rows and 30 cm in the rows, but 75–90 cm between the rows and 10–15 cm in the rows makes weeding easier. Climbing beans are usually planted on hills 90–120 cm apart with 4–6 seeds per hill, later thinned out to 3–4 plants; they may also be planted in rows at a spacing of 90–120 × 15–30 cm. Depth of sowing varies from 3–6 cm, depending on the soil. The seed rate varies with seed size and spacing, but is usually ca 20–55 kg/ha; in the U.S.A. ca 80 kg/ha is used for bush beans and ca 20–35 kg/ha

16. For a description of cv. Canadian Wonder see Tracy (1907, p. 60) and Hedrick et al. (1931, p. 76–77).

for climbing beans (Purseglove, 1968). Terra (1966) comes to a seed rate of 60–120 kg/ha for bush beans and 25–60 kg/ha for climbing beans.

Flat cultivation is preferred to ridges: disturbance of the soil should be avoided because of damage of the collar of the plant involving stem and collar rots; therefore clean, shallow cultivation should be practiced (Stanton et al., 1966; Choudhury, in: Kachroo, 1970). In some arid subtropical regions the crop is sometimes irrigated. Beans are shallow-rooted and are sensitive to an oversupply of water. Good yields are possible with very little moisture applied during the season. Light irrigation is favourable as heavy flooding is not only a waste of water, but may also result in excessive vine growth delaying maturity (Choudhury, in: Kachroo, 1970). In peasant cultivation in Africa the crop is seldom manured.

Snap beans are harvested before the pods are fully grown, when the seeds are still small and do not cause the pods to bulge. Picking begins 2–4 weeks after the first flowers have appeared, in early cultivars 7–8 weeks after sowing. They should be picked every 3–4 days and the number of pickings is greater in climbing cultivars than in bushy ones. The average yield of snap beans is ca 5 tons/ha, but considerably higher yields have been recorded. Dry beans are harvested as soon as a considerable percentage of the pods are fully mature and have turned yellow. Some cultivars have a tendency to shatter. Usually the entire plants are pulled out, and then dried and threshed (Purseglove, 1968). The plants are tied in bunches and hung to dry on frames. In regions with a marked dry season the pulled plants can be left to ripen in the field before threshing. The threshed seed may be dried on trays, or, if the plants have been allowed to dry thoroughly on the field, the seed may be transferred directly to the store (Stanton et al., 1966). In dry areas where irrigation is practiced, it is possible to further maturing by withholding water (Choudhury, in: Kachroo, 1970). In Africa the yield of dried beans is about 560–1120 kg/ha; in the U.S.A. the average is about 1350 kg/ha (Purseglove, 1968).

In Ethiopia, *Phaseolus vulgaris* is a very common crop and covers a considerable acreage each year. It is mainly grown as a cash crop. The cultivars commonly grown are the white, red or brown-seeded types. They grow best at altitudes between 1700 and 2000 m. Bush cultivars are found mainly in the Chercher region, Shoa and Arussi, whereas climbing cultivars occur in the more humid south-western part of the country.

In the Chercher region it is the major leguminous crop in the 'durra-complex'. Its importance is not only due to its wide distribution throughout this area, but also to its early maturing and low moisture requirements, which make it a dependable catch crop when staple cereals fail. In most areas two harvests are possible between April and December. Several cultivars are found in each settlement. Nearly always common beans are interplanted with sorghum and maize, and the preparation of the seedbed is the same as that for the cereals. Seeds are broadcast in April. By mid-July the pods ripen, and entire plants are uprooted and carried to the edge of the field where a threshing floor has been prepared. Immediately the same field is reseeded; the seeds are scattered between the growing sorghum and maize and covered with

earth. The second crop of beans is harvested shortly before the sorghum matures, usually late November (Brooke, 1958).

Uses

The young pods and ripe seeds are eaten, so, to a lesser extent, are the green-shelled seeds. In some parts of the tropics young leaves are used as a vegetable (Purseglove, 1968), as e.g. by the Javanese (in Indonesia) who eat young and even old leaves as pot herbs (Ochse, 1931). In the temperate countries *P. vulgaris* is grown mainly for the green immature pods which are eaten as a vegetable and are also canned and frozen. The dried seeds are also cooked with tomato sauce and canned. The straw is used as forage (Purseglove, 1968). It is of little importance for fodder or soil improvement (Whyte et al., 1953).

In Ethiopia dry seeds are used in vegetable 'wot". Most of them go to canneries, and only a fraction of the production is exported. On some markets (like Addis Abeba, Dire Dawa, Harar, Jima) small amounts of snap beans have been observed by the author.

Protein content

Young pods: 1–4% (Terra, 1966), 6.1% (Purseglove, 1968); ripe seeds: 22% (Burkill, 1966; Purseglove, 1968; Terra, 1966).

The first limiting amino acids are methionine and cystine followed by tryptophane (Aykroyd & Doughty, 1964).

(11) Pisum sativum L.

'*Pisum*': ancient Latin name for a plant, derived from Greek 'pison', generally indicating some pea.
'*sativum*': see *Lathyrus sativus*.

Typification: see under cv.-group Sativum.

(11A) Cv.-group Abyssinicum — Fig. 20; Plate 53–55

'*Abyssinicum*': derived from 'Abyssinia' (cf. Greek 'abys'), a name now obsolete for Ethiopia.

Alefeld, Bonplandia 9: p. 126 (1861), being *Pisum sativum* L. var. *abyssinicum* (A. Br.) Alef.
Type: Ethiopia: Tigre, montibus prope Djeladjeranne; Schimper 1866 (P, neotype!; duplicate at K![17]).

17. The sheet of Kew consists of 2 elements: 1 specimen of cv.-group Abyssinicum and 1 specimen of cv.-group Sativum (with white flowers).

Synonyms

Pisum abyssinicum A. Braun, Flora 24(1): p. 269 (1941) (basionym).
Pisum sativum var. *abyssinicum* (A. Br.) Alef., Bonplandia 9: p. 126 (1861).
Pisum arvense L. var. *abyssinicum* (A. Br.) Alef. ex Engler, Ueb. Hochgeb. Flora trop. Afrika: p. 265 (1892).
Pisum sativum var. *elatius* (Stev.) Beck f. *abyssinicum* (A. Br.) Gams, in: Hegi, Ill. Flora Mittel-Europa 4(3): p. 1013 (1924).
Pisum sativum ssp. *abyssinicum* (A. Br.) Gov., Bull. appl. Bot. Genet. Pl. Breed. Leningrad 24(2): p. 423 (1929-1930).

Literature

1841: Braun, Flora 24(1): p. 269-270. (tax.)
1924: Gams, in: Hegi, Illustr. Flora 4(3): p. 1613. (tax.)
1930: Govorov, Bull. appl. Bot. Genet. Pl. Breed. 24(2): p. 422–423, 425. (tax.)
1937: Govorov, in: Vavilov & Wulff, eds, Koultournaja Flora SSSR 4: p. 250-251. (tax.)
1955: Cufodontis, Enumeratio, Bull. Jard. bot. État Brux. 25(2): p. 311. (tax.)
1971: Gentry, Pl. Genet. Resour. Newsl. 26: p. 20-22. (agric.)
1972: Gillett, Kew Bull. 27(1): p. 117, 119, 120, 124. (tax.)

Local names: agarea atar (Amarinia); dekokko (?).
Trade name: Abyssinian pea (English).

Geographic distribution

The Abyssinian pea is found in northern Ethiopia in the high mountains forming the eastern escarpment in Tigre and Wollo provinces. It occurs also along the road to Asella in Arussi province. Govorov (1930) found it mixed with other peas, chickpea and horse bean in the regions of Addis Abeba and Hararge, where in some locations it was grown as a pure crop. The author encountered pure seed samples as well as mixtures at various market places in Tigre (Enda Medhane Alem), Wollo (Bati, Dese, Woldya, Alamata), Shoa (Shashamane), Arussi (Asella) and Hararge (Harar, Jijiga). J. J. F. E. de Wilde collected seed samples in Wollo (Robi) and in Bale (Adaba, Habbe), and C. J. P. Seegeler in Bale (Goba).

This pea differs markedly from the ordinary Ethiopean cultivars: it has leaves with one pair of leaflets, the flowers are small and red-purple, and the seeds are globose and slightly glossy, with a black hilum.

Description

A short, climbing, few-branched, glabrous, waxy annual. Taproot well-developed. Sometimes globular nodules present on taproot of young plants.

Stems slightly angular, ribbed, light green with some purple, with no or few basal branches.

Stipulae large, leaf-like, larger than the leaflets, obliquely ovate to -obovate, acutely dentate at outer margin with prominent dents at basal part, sometimes inner margin

with small dents; top as a rule mucronate.

Leaves alternate, pinnate, with one pair of leaflets, with rachis represented by a simple but as a rule branched tendril which is often longer than the petiole. Petiole (2.5–)3.0–5.0(–7.0) cm long.

Leaflets opposite, shortly petioluled, ovate to obovate, sometimes rhomboid or obtriangular, (1.5–)2.0–4.0(–5.0) × (1.0–)1.2–2.8(–3.2) cm, cuneate at base, with edge in basal part smooth and in upper part acutely dentate, either mucronate or acutely dentate at top.

Stipellae absent.

Inflorescence an axillary raceme (1 flower); peduncle short, (0–)1.5–3.5(–4.5) cm long, rarely purple, sometimes top slightly pubescent; rachis not ending into a filiform apex; bracts absent or nearly so; pedicel ca 0.5 cm long, sometimes purple.

Calyx campanulate; tube gibbous dorsally, ca 4 mm long; lobes 5, subequal, narrowly triangular, 4–7 mm long.

Corolla small. Standard erect and not spreading, broadly obovate, ca 14 × ca 15 mm, clawed, obcordate and as a rule mucronate at top, bi-'pocketed' (and near the claw with a slightly developed small 'pocket' at either side), red-purple (turning violet-blue). Wings obovate, ca 13 × ca 7 mm, clawed, auriculate, bi-'pocketed', obtuse at top, red-purple (turning violet), slightly adhering to the keel. Keel boat-shaped, ca 10 × ca 6 mm, clawed, entirely split dorsally, ventrally split near the base, with the apical part frilled (narrowly winged), bi-auriculate, bi-'pocketed', white–light green.

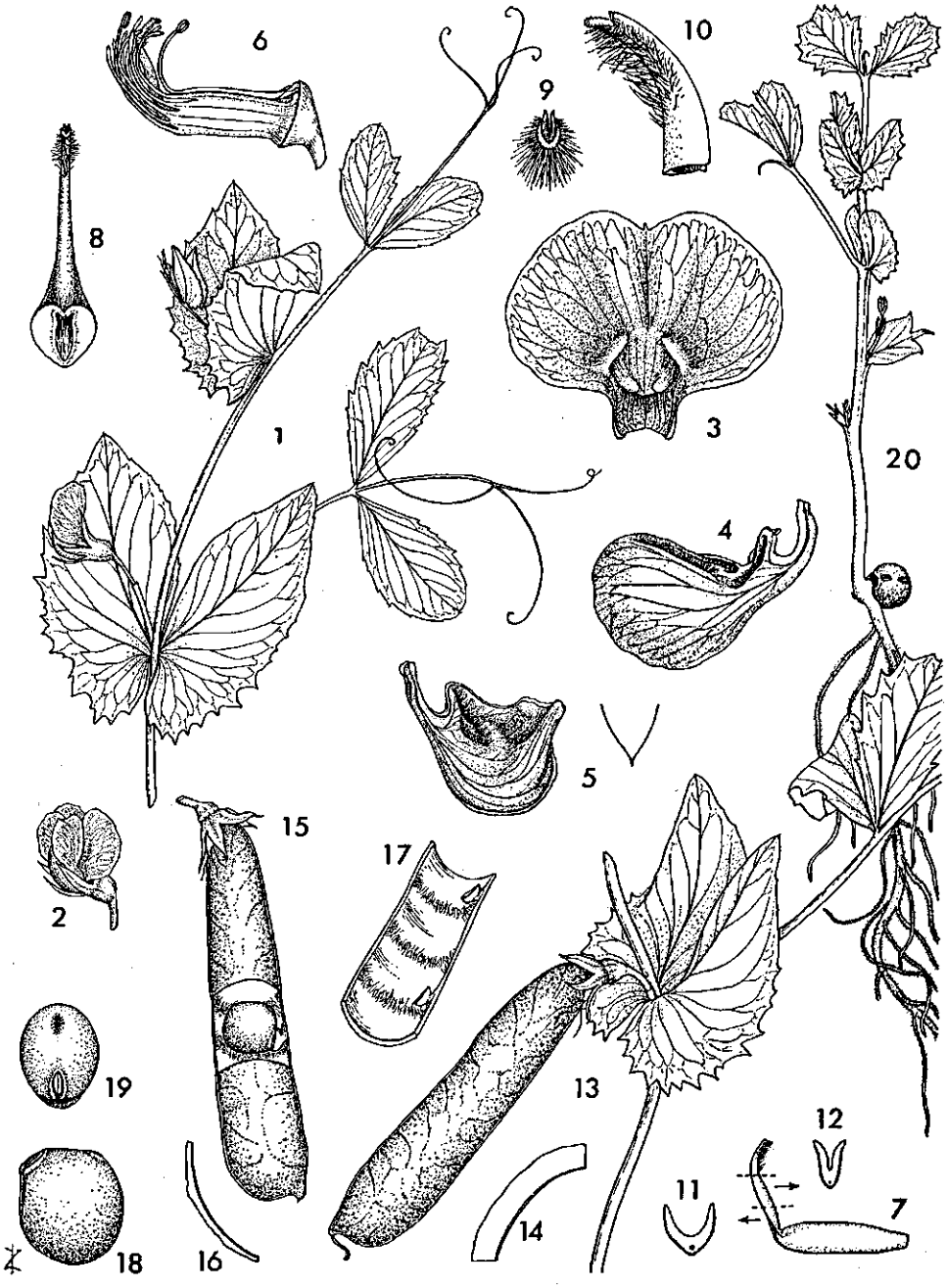
Androecium: Stamens diadelphous (9+1). Vexillary stamen free, ca 10 mm long, gradually winged towards the base. Staminal sheath ca 5 mm long; free part of filaments slightly alternately longer and shorter, when longer 7 mm long, when shorter 6 mm long, slightly winged. Anthers obliquely attached, ellipsoid, ca 0.5 mm in diam., basi–dorsifixed, light yellow.

Disk absent.

Gynoecium: Ovary sessile or nearly so, ca 7 mm long, glabrous, gradually flattening the sterile part) dorsally towards the top, 5(–7)-ovulate. Style abruptly upturned, ca 5 mm long, conspicuously winged, V-shaped in transverse section, glabrous with an adaxial tuft of hairs near the stigma. Stigma: the truncate, glandular-papillate ending of the style.

Pod oblong, slender, pod wall not fleshy when mature (stiff papery inner parchment present, but difficult to detach from outer pod wall), bulging over the seeds, (3.5–) 4.5–5.5(–6.5) × 1–1.5 cm, cuneate at base, slightly beaked or not, waxy (when

Fig. 20. *Pisum sativum* L. cv. Bati Ater. – 1. branch with leaves and inflorescence (⅚×); 2. flower (⅚×); 3. standard, adaxial view (2½×); 4. wing, abaxial view (2½×); 5. keel (2½×), with schematic representation of the frilled ventral part; 6. staminal sheath + pistil (2½×); 7. pistil (2½×); 8. style + stigma, adaxial view (5×); 9. stigma, dorsal view (10×); 10. stigma, side view (12×); 11. transverse section of basal part of style (12×); 12. idem, of apical part of style (12×); 13. branch with immature pod (⅚×); 14. transverse section of wall of immature pod (2½×); 15. mature pod (⅚×); 16.



transverse section of wall of mature pod (2½×); 17. inner pod wall with pubescence (⁵/₆×); 18. seed, lateral view (2½×); 19. seed, with hilum (2½×); 20. seedling (⁵/₆×). – 1. WP 7745; 2. WP 7751 (spirit mat.); 3–12. WP 7751 (spirit mat.); 13. WP 7746 (including spirit mat.); 14. WP 7746 (spirit mat.); 15–16. WP 7731 (spirit mat.); 17. WP 7746 (spirit mat.); 18–19. WP 4018A; 20. WP 7744 (spirit mat.).

immature), reticulately veined, with veins more prominent when mature, with inner surface of pod wall finely pubescent along both sutures as well as between the seeds, 2–5(–7)-seeded. Sometimes dorsal suture purple.

Seeds globose or globose-angular, smooth, slightly glossy, sometimes very slightly wrinkled, 5–7 mm in diam., dark violet, grey-green, brown or grey-green to brown with violet spots. Hilum small, elliptic, black. Cotyledons light yellow.

Seedling with hypogeal germination; epicotyl sometimes purple. First two leaves simple, scale-like and largely fused with two lateral scale-like 'stipulae', with margin second leaf partly denticulate. Top first leaf tri-dentate, often the lateral teeth smaller, sometimes central tooth elongated into a winged subulate mucro. Top second leaf tri-dentate, with lateral teeth prominent and approaching the shape of stipulae, with central tooth as a rule markedly elongated into a winged subulate mucro. Leaflets of first compound leaf with less marginal teeth than the following leaves; tendril sometimes winged.

Taxonomic notes

(1) According to A. Braun (1841), a collection of Ethiopian seeds of W. Schimper arrived at the Grand Ducal Botanical Garden of Karlsruhe in 1840. Seeds of *Pisum sativum* cv.-group Abyssinicum, from crops grown around Adua, were sown in 1840 and the resulting plants were described and published by Braun in 1841. However, neither herbarium specimens of these plants raised in 1840, nor seeds of the original sample sent by Schimper are nowadays present in the Landessammlungen für Naturkunde at Karlsruhe.

On 23 October 1840, Schimper collected two specimens of this particular pea, most likely also near Adua: no. 1862 n. 960 from 'Wongi (Atoh Khebede) dry areas in neighbourhood'[18] and no. 1866 from 'montibus prope Djeladjeranne'. 'Atoh' (now written Ato) is the word for Mister in Ethiopia, so 'Atoh Khebede' apparently indicates the person from whom Schimper received the Wongi collection.[19] I have been able to locate only the second locality on the map (Gillett, 1972).

I designate one of the specimens collected by Schimper (viz. 1866) as the neotype of this taxon (P).

18. According to Gentry (Pl. Genet. Resour. Newsl. 25: p. 10 (1971)) this specimen is at Kew. However, in 1973, it has not been found there by the author.

19. In 1962, Frahm-Leliveld collected seeds of *P. sativum*, including cv.-group Abyssinicum, at the southern border of the Wonji sugar estate, in a rather dry area known under the name 'Ato Kebede'. Wongi is not listed by Gillett (1972) as one of the localities in north Ethiopia were Schimper has been collecting. Moreover, the Schimper specimen from 'Wongi (Atoh Khebede) dry areas in neighbourhood' carries two numbers (Gentry, 1971), which points to a renumbering by Schimper for some reason. It may be tempting to suppose that Schimper's specimen came from the Ato Kebede area of Wonji in Shoa. But, since he never was there, according to Gillett, it is unlikely that Schimper's Wongi (Atoh Khebede) is identical with Wonji (Ato Kebede) of Frahm-Leliveld.

(2) Govorov (1930) mentions in addition to the description of Braun the following characteristics: the occurrence of dark violet seeds (var. *vavilovianum* Gov.) as well as greenish-grey seeds with anthocyanin spots (var. *violaceo-punctatum* Gov.) next to grey-green seeds (var. *viridulo-griseum* Gov.), a black hilum, the absence of a purple spot at the base of the stipulae, and the anthocyanin often present in the young stages of the plant. These findings have been confirmed in this study, though no anthocyanin has been found in the leaves.

(3) Seed types collected in Ethiopia.

(a) Seeds dark violet. I designate this taxon as cv. Vavilovianum (based on WP 63, WP 278, WP 1066 and WP 5833).

(b) Seeds grey-green. I designate this taxon as cv. Viridulo-Griseum (based on J. J. de Wilde 7181).

(c) Seeds brown. I designate this taxon as cv. Bati Ater (based on WP 4018A, WP 7744, WP 7745 and WP 7746).

(d) Seeds with violet spots. I designate this taxon as cv. Speckled Jijiga (based on WP 3494D, WP 7739, WP 7740 and WP 7741).

(4) Govorov (1930) pointed at introgression between the two groups of Ethiopian peas. Gentry (1971) mentioned for the Asella region the occurrence of seeds with dark specklings on an olive-green base which frequently are angular like the common field pea. This indeed suggests hybridization between both types, moreover, because they were growing side by side. Similar situations in the north, however, did not show any introgression. Neither were seeds with violet specklings collected in north Ethiopia by the author.

(5) In general, plants raised in the field at Wageningen are more vigorous. Apart from those in height the following differences were found

	Petiole length in cm	Leaflet		Seed diameter in cm
		length in cm	width in cm	
Grown at Wageningen	(2.5–) 4.0–5.0 (–7.0)	(2.5–) 3.0–4.0 (–5.0)	(1.0–) 1.5–2.8 (–3.2)	0.6–0.8
Grown in Ethiopia	(2.5–) 3.0–3.7 (–4.5)	(1.5–) 2.0–2.7 (–3.5)	(1.0–) 1.3–2.2 (–2.7)	0.5–0.7

(6) Within the Abyssinicum collection raised at Wageningen, together with other Ethiopian peas (from seeds collected at market places), two types of pods were found.

(a) Slender, pod wall thin, stiff papery inner parchment present but difficult to detach from outer pod wall, hilum black, seeds somewhat smaller and more globular, hard on spirit.

(b) To the top broader than (a), pod wall thick and fleshy, stiff papery inner parchment present and easily detachable from outer pod wall, hilum not black, seeds larger and more angular, more soft when preserved on spirit.

It may be that (b) is a younger stage of (a), or possibly the result of hybridization between cv.-group Abyssinicum and cv.-group Sativum.

(7) The description is based on the following specimens.

Tigre	Adi Shoa: Sl 356.
Wollo	Robi: J. J. Wilde 7181; Dese market: WP 4021B; Bati market: WP 4018A–WP 4018B.
Shoa	in field, 5 km south of Nazret on Asella road: WP 1507.
Bale	Adaba market: J. J. de Wilde 7370A, 7370B; Goba market: Sl 1223; Habbe market: J. J. de Wilde 7368B.
Arussi	Asella market: WP 2991A–WP 2991B, WP 2991C2, WP 2991D2.
Hararge	Harar market: WP 63; Jijiga market: WP 3494A–WP 3494D, Sl 356; garden Alemaya: WP 278, WP 1066.
Grown at Wageningen	WP 5830–WP 5835, WP 6867–WP 6870, WP 6874, WP 7726–WP 7736, WP 7739–WP 7752; Frahm–Leliveld 62344 from seeds obtained from Wonji (mixture) (K!).

Coll. Quartin-Dillon et Petit (dernier envoi, 1844): *Pisum abyssinicum* A. Braun, Abyssinia, sine loco (P!).

Coll. Quartin-Dillon et Petit (ex herb. A. de Franqueville 18, herb. E. Cosson 18): *Pisum abyssinicum* A. Braun, Abyssinia, sine loco. One of the sheets consists of a mixture of cv.-group Abyssinicum and cv.-group Sativum (P!).

Ecology

For this interesting pea the ecological requirements seem to be the same as for *P. sativum* cv.-group Sativum. Its geographic distribution, however, is limited to the highland regions of Tigre and Wollo. Some disjunct collections made by Gentry in Arussi (Gentry, 1971), by the author in Arussi as well as in the eastern part of the Chercher Highlands and by J. J. F. E. de Wilde and C. J. P. Seegeler in northern Bale point to introduction by settlers entering from the north. The crop is grown mostly in the main rainy season like cv.-group Sativum.

Husbandry

Farmers cultivating cv.-group Abyssinicum stated that it matures in 3 to 4 months after sowing, whereas the normal pea requires 5 months. The pods do not retain the seeds as well as those of cv.-group Sativum.

Cv.-group Abyssinicum commanded in the markets 20–30% higher prices than cv.-group Sativum. Whether this is due to the relative scarcity of the former or to superior culinary qualities could not been determined (Gentry, 1971).

Uses

The seeds are used in 'wot".

Protein content

Ripe seeds: 20–30% (Depart. of Human Nutrition, Agricultural University, Wageningen).

(11B) Cv.-group Sativum

Figs 21, 22; Plates 56–59

Linnaeus, Sp. Pl. ed. 1: p. 727 (1753).

Type: habitat in Europae agris; '*Pisum* stipulis inferne crenatis, ..., pedunculis multifloris' (LINN, specimen 903.1, lecto.!).

Synonyms

Pisum sativum var. *arvense* (auct. non L.) Schrank, Baier. Fl. 2: p. 252–253 (1789).
Pisum sativum ssp. *arvense* (auct. non L.) Poir., in: Encycl. 5: p. 456 (1804).
Pisum sativum var. *hortense* Neilr., in: Fl. Nied.-Oesterr.: p. 964 (1859).
All cultivated peas mentioned by Alefeld, Landw. Flora: p. 37-55 (1866), except *P. sativum* var. *abyssinicum* (A. Br.) Alef.
Pisum sativum ssp. *arvense* (auct. non L.) Celak., Prod. Fl. Böhmen. 3: p. 686 (1874).
Pisum commune Clavaud, Act. Linn. Soc. Bord. 38: p. 572 (1884).
Pisum sativum var. *typicum* Beck, Rchb. Ic. 22: p. 209.
Pisum sativum ssp. *hortense* Asch. & Gr., Syn. 6(2): p. 1066 (1906-1910).
All cultivated peas mentioned by Gams, in: Hegi, Illustr. Fl. Mittel-Europa 4(3): p. 1613-1615 (1924), except *P. sativum* var. *elatius* (Stev.) Beck f. *abyssinicum* (A. Br.) Gams.
Pisum sativum ssp. *arvense* (auct. non L.) Poir. proles *aethiopicum* Gov., Bull. appl. Bot. Genet. Pl. Breed. Leningrad 24(2): p. 423 (1929-1930).
Pisum sativum ssp. *sativum* proles *subaethiopicum* Gov., l.c. p. 424.
Pisum sativum ssp. *commune* (Clavaud) Gov. convar. *aethiopicum* Gov., in: Koultournaja Flora SSSR 4: p. 287 (1937).

Literature

1804: Poiret, in: Lamarck, Encycl. Méth. 5: p. 455-456. (tax.)
1883: Candolle, de, Origine des plantes cultivées: p. 262-264. (tax.)
1906-1910: Ascherson & Graebner, Synopsis 6(2): p. 1063-1067. (tax.)
1924: Gams, in: Hegi, Illustr. Flora 4(3): p. 1610-1618. (tax. + agric.)
1930: Govorov, Bull. appl. Bot. Genet. Pl. Breed. 24(2): p. 420-431. (tax. + agric.)
1937: Govorov, in: Vavilov & Wulff, eds, Koultournaja Flora SSSR 4: p. 287-288. (tax.)
1953: Whyte et al., Legumes in agriculture: p. 305-306. (agric.)
1954: The Agriculture of Ethiopia 1: p. 32. (agric.)
1955: Cufodontis, Enumeratio, Bull. Jard. bot. État Brux. 25(2): p. 311. (tax.)
1956: Lamprecht, Agr. Hort. Genet. 14: p. 1-4. (tax.)
1957: Kuls, Petermanns geogr. Mitt. 101: p. 248 (agric.)
1958: Brooke, Econ. Bot. 12: p. 202. (agric.)
1958: Kuls, Frankf. Geogr. Hft 32: p. 64, 66 (agric.)
1960: Simoons, Northwest Ethiopia: p. 202. (agric.)
1961: Huffnagel et al., Agriculture in Ethiopia: p. 202. (agric.)
1964: Aykroyd & Doughty, Legumes in human nutrition: p. 109-110, 118. (agric.)
1966: Stanton et al., Grain legumes in Africa: p. 116. (agric.)
1968: Purseglove, Tropical Crops, Dicotyl. 1: p. 311-315. (tax. + agric.)
1971: Gentry, Pl. Genet. Resour. Newsl. 26: p. 20-23. (agric.)

Local names: ater, attur (Amarinia); ain-ater, tukur-ater, ater-schoa (Tigrinia); atari, danguleh (Gallinia); atero, gishi-shato (Kaffinia).
Trade names: pea, garden pea, field pea (English); pois (French).

Geographic distribution

Peas are probably native in south-western Asia and have been cultivated there since ancient times. They reached the Greek via the Black Sea, and the Latin and Germanic tribes got them through the Greek. They spread to India and China, and reached the mountain region of Ethiopia and east and central Africa before the arrival of the Europeans. The crop is now grown in all temperate regions. It has been adapted to cool weather and does not thrive in hot and dry regions. Peas are grown sometimes in subtropical and tropical areas during the cold season. They are grown as a pulse or as a garden crop (Purseglove, 1968; Whyte et al., 1953).

In Ethiopia, extensive areas of the central and northern part of the Ethiopian Highlands are cultivated with this pea, but it is also found in other highland regions. It is found on almost every market.

Description

A climbing, glabrous, waxy annual. Taproot well-developed with many strong laterals. Infrequently globular nodules present on taproot of young plants (not seen on specimens collected in Ethiopia).

Stems angular–terete, slender, with no or few basal branches; internodes hollow and sometimes purple at base.

Stipulae large, leaf-like, larger than the leaflets, oblique ovate to -obovate, sometimes up to 10 cm long, acutely dentate at lower part of outer margin, sometimes with outer and inner margin completely, acutely dentate, mucronate at top, sometimes purple at base.

Leaves alternate, pinnate, with (1–)2(–3) pairs of leaflets; petiole (2.0–)4.0–6.0(–7.5) cm long, hollow; rachis hollow, produced into a strongly branched tendril, as a rule longer than the petiole.

Leaflets opposite or sub-opposite, short-petioluled, ovate or obovate, sometimes more or less rhomboid and asymmetrical, (1.5–)2.5–6.5(–8.0) × (1.0–)1.5–3.5(–4.0) cm, cuneate at base, with either smooth or partly, resp. entirely acutely dentate, either mucronate or acuminate at top.

Stipellae absent.

Inflorescence an axillary raceme (1–2 flowers); peduncle slender, hollow, (1.5–) 3.5–12.0(–22.0) cm long, sometimes purplish especially near base of pedicel(s); rachis as a rule ending in a subulate apex (minute to ca 3 cm long, mostly smaller when 2 flowers are present); bracts 0–2 per flower, variable in shape and size (sometimes ca 2 cm long, ca 1.5 cm wide, acutely dentate); pedicel 0.5–1.5 cm long, sometimes purple.

Calyx campanulate; tube gibbous dorsally, with base somewhat fleshy becoming shallowly saucer-shaped when older and subtending the thin upper calyx-lobes, ca 6 mm long; lobes 5, subequal, (narrowly) triangular, 6–10 mm long.

Corolla: Standard erect and spreading, depressed obovate, 20–24(–27) × (22–)24–28

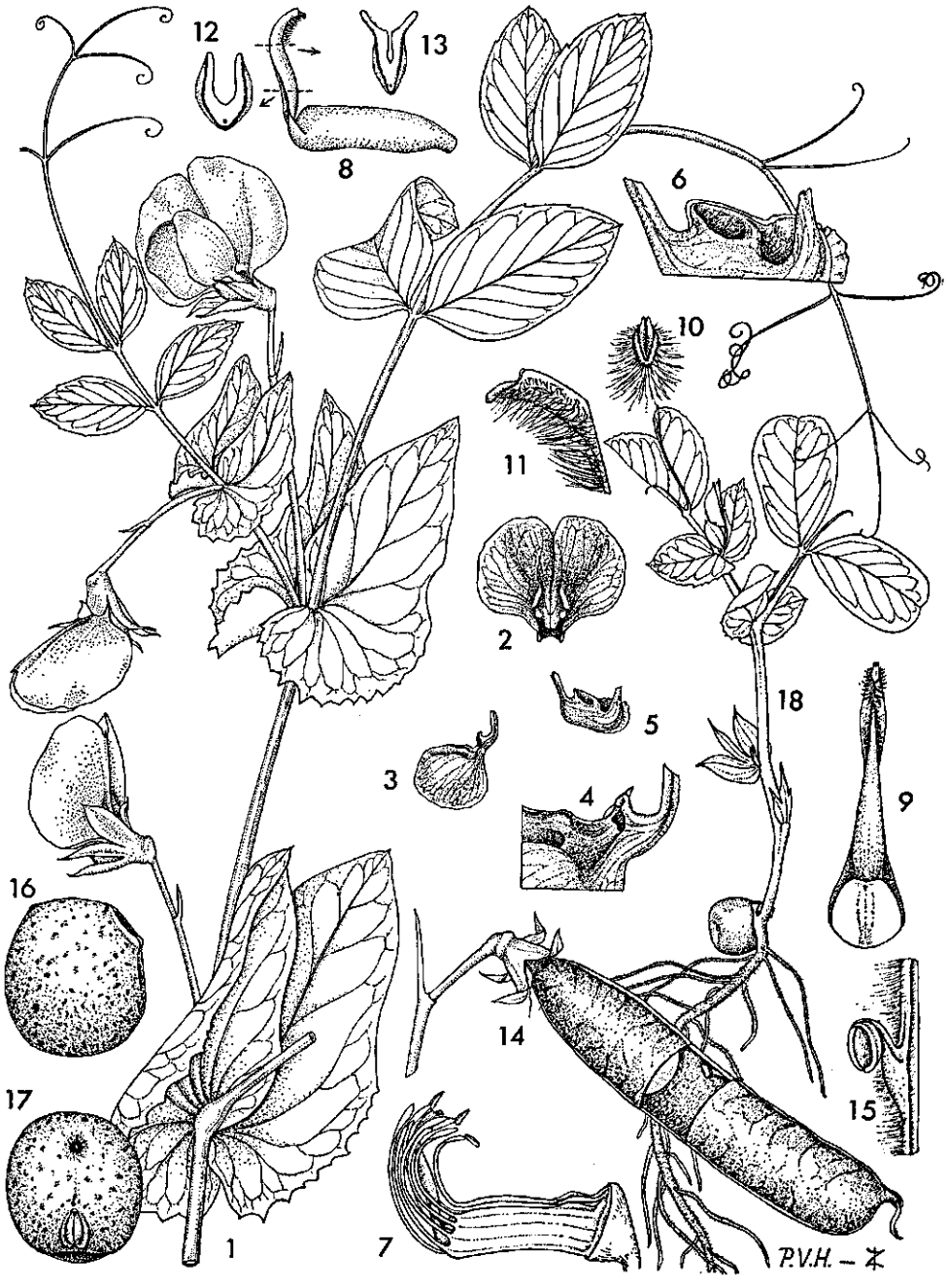


Fig. 21. *Pisum sativum* L. cv. Speckled Shoa. – 1. branch with leaves and inflorescence (5/6×); 2. standard, adaxial view (5/6×); 3. wing, abaxial view (5/6×); 4. detail wing, abaxial view (2½×); 5. keel (5/6×); 6. detail keel (2½×); 7. staminal sheath + pistil (2½×); 8. pistil (2½×); 9. style + stigma, adaxial view (5×); 10. stigma, dorsal view (10×); 11. stigma, side view (10×); 12. transverse section of basal part of style (10×); 13. idem, of apical part of style (10×); 14. pod (5/6×); 15. funicle (2½×); 16. seed, lateral view (2½×); 17. seed, with hilum (2½×); 18. seedling (5/6×). – 1. WP 7886 (including spirit mat.), WP 7887; 2–13. WP 7886 (spirit mat.); 14–15. WP 7887 (spirit mat.); 16–17. WP 5490D$_2$; 18. WP 7885 (spirit mat.).

(–34) mm, clawed, obcordate and mucronate at top, bi-'pocketed', with some smaller 'pockets' near the claw, white or red-purple (and in the latter case turning to violet-blue or blue). Wings broadly obovate, (17–)20(–23) × (11–)12(–17) mm, clawed, auriculate, bi-'pocketed', obtuse at top, white to green-white or red-purple (and then turning to purple or violet), adherent to the keel. Keel boat-shaped, ca 13 × ca 8 mm, clawed, entirely split dorsally, ventrally split near the base, with the apical part frilled (narrowly winged), bi-'pocketed', white–light green.

Androecium: Stamens diadelphous (9+1). Vexillary stamen free, ca 14 mm long, basal part (ca 8 mm) winged, apical part slightly winged. Staminal sheath ca 8 mm long; free part of filaments alternately slightly longer and shorter, when longer 7–8 mm long; when shorter 6.5–7 mm long, slightly winged. Anthers ellipsoid, ca 1 mm long, basi–dorsifixed, light yellow.

Disk absent.

Gynoecium: Ovary subsessile, ca 9(–12.5) mm long, glabrous, flattening (the sterile part) near the top, 5–9-ovulate. Style abruptly upturned, ca 7 mm long, conspicuously winged, V-shaped in transverse section, glabrous, with an adaxial tuft of hairs near the stigma. Stigma: the truncate, glandular-papillate ending of the style.

Pod oblong, slender, (4.0–)5.5–8.0(–9.5) × 1.0–1.5(–1.8) cm, attenuate at base, beaked, (5–)6–8(–9)-seeded; pod wall not fleshy and reticulately veined when mature; young pods fleshy and waxy; inner layer of pod wall parchment-like (stiff, papery), and in young pod easily detachable from outer pod wall; inner surface of pod wall slightly finely pubescent, esp. along the ventral suture; along the dorsal suture a few sparse hairs are present between the funiculi. Sometimes dorsal suture purple.

Seeds globose or globose–angular, smooth or slightly wrinkled, 6–8 mm in diam., white with an orange tinge, green, orange-brown to brown, dark violet, green or brown with violet spots, or with mosaic pattern. Hilum small, elliptic, light coloured, sometimes black. Cotyledons light yellow.

Seedling with hypogeal germination. Epicotyl and stipulae at base sometimes purple. First two leaves simple, scale-like and largely fused with two lateral scale-like 'stipulae'. Top first leaf tri-dentate, the lateral teeth as a rule smaller. Top second leaf tri-dentate, lateral teeth prominent, frequently approaching the shape of the stipulae. First compound leaf bi-foliolate; leaflets either entire or dentate; top mucronate either obcordate or obtuse, sometimes acuminate. Petioles of lower leaves grooved above.

Taxonomic notes

(1) In Sp. Pl. ed. 1 the diagnosis of *Pisum sativum* is the following: '*Pisum* stipulis inferne rotundatis crenatis, petiolis teretibus, pedunculis multifloris'. Hort. ups. 215. No specimen has been found on which the description in Hort Ups. has been based. In Hort. Cliff. p. 369 the diagnosis is less precise, being '*Pisum* stipulis crenatis'. Typification with a specimen in LINN then seems preferable.

In LINN a specimen with flowers (903.1) is present with the reference by number to Sp. Pl. ed. 1. It has been selected as the lectotype of *Pisum sativum* L. (On the

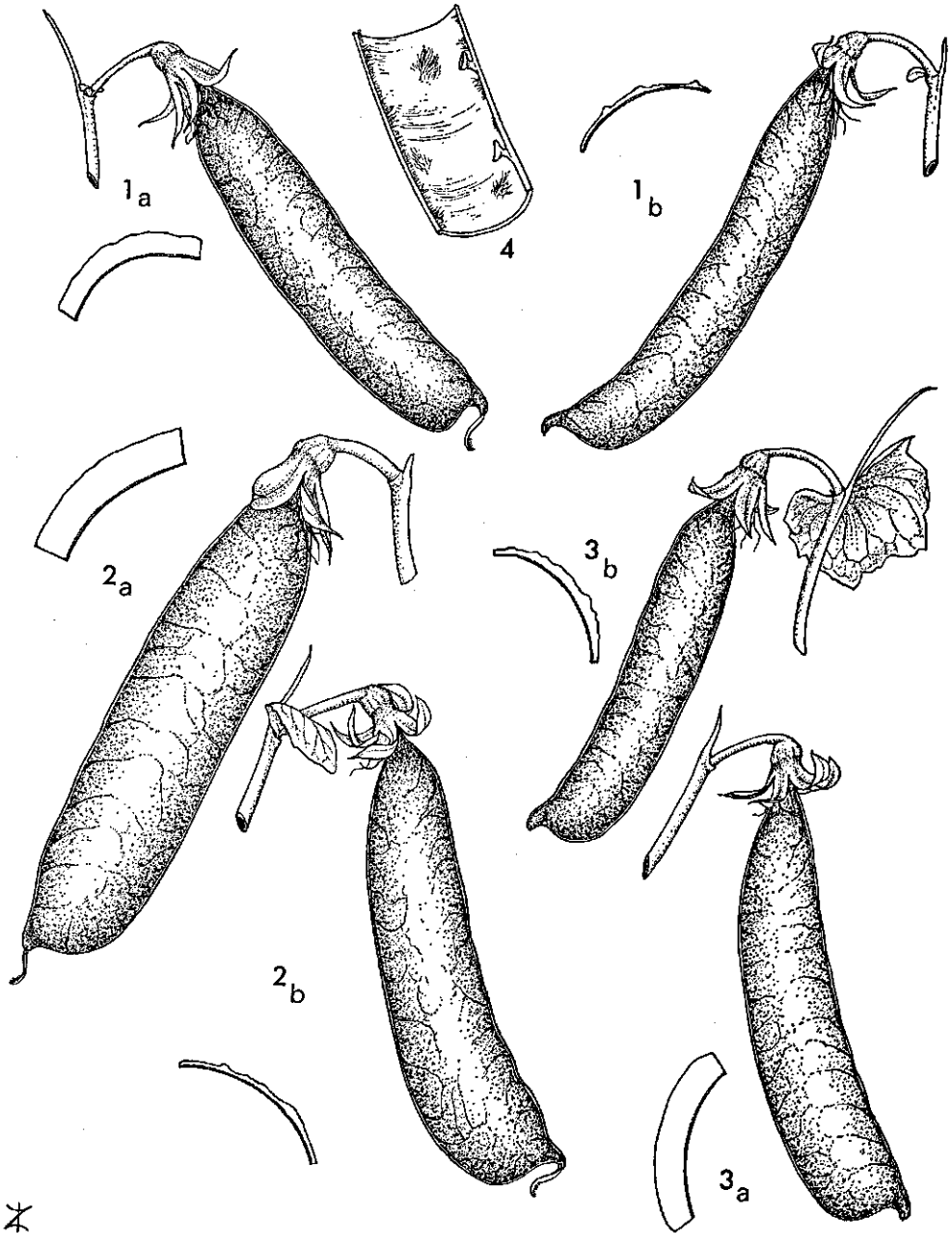


Fig. 22. *Pisum sativum* L. cv. Speckled Shoa. – 1.a immature pod + transverse section of pod wall (2½×). Cv. Addis Abeba. – 1.b mature pod + transverse section of pod wall (2½×). Cv. White Adere. – 2.a immature pod + transverse section of pod wall (2½×); 2.b mature pod + transverse section of pod wall (2½×). Cv. Shashamane Ater. – 3.a immature pod + transverse section of pod wall (2½×); 3.b mature pod + transverse section of pod wall (2½×); 4. general picture for the depicted cvs; inner pod wall with pubescence. – 1.a WP 7887 (spirit mat.); 1.b WP 7770 (spirit mat.); 2.a WP 7754 (spirit mat.); 2.b WP 8693 (spirit mat.); 3.a WP 7765 (spirit mat.); 3.b WP 7837 (spirit mat.).

microfiche of LINN specimen 903.1 the reference to Sp. Pl. ed. 1 is not visible).

(2) Linnaeus (1753) considered all cultivated peas to belong to *Pisum sativum*, for which he gave the following diagnosis: '*Pisum* stipulis inferne rotundatis crenatis, petiolis teretibus, pedunculis multifloris'. It is cultivated in Europe ('habitat in Europae agris'). Since the colour of the flowers and the number of leaflets are not mentioned in the diagnosis, and considering Linnaeus's earlier publications, it may be assumed that he considered these characteristics unimportant when segregating *P. sativum* as a whole and also with regard to infraspecific taxa. According to the references used by Linnaeus, both white and purple flowers occur within *Pisum sativum*. Bauhin (1623), as cited, mentions '*Pisum* hortense majus' which has purple flowers and sometimes either white or partly white and partly purple flowers (Linn. Sp. Pl. 'β'); also peas without a stiff pod wall ('Pisa sine cortice duriore': Linn. Sp. Pl. 'γ'), as well as *Pisum umbellatum* (Linn. Sp. Pl. 'δ') and '*P.* majus quadratum' (Linn. Sp. Pl. 'ε'). In Hortus Cliffortianus (1737) as well as in Hortus Upsaliensis (1748) several references to *P. arvense* are made, quoted from Bauhin, Tournefort, and others. In Sp. Pl. ed. 1 *P. arvense* appears as a second species (with *P. sativum*), but Linnaeus makes no reference to the earlier authors quoted in Hortus Cliffortianus and Hortus Upsaliensis and he based *P. arvense* on his own collection (It. W. Goth.) and other publications by Bauhin and Morison. Only one author as cited by Linnaeus, viz Tournefort, has mentioned the colour of the flowers as being rose-red. Since the pre-Linnaean *P. arvense* was included by Linnaeus in his *P. sativum* of 1753, it can be concluded by indirect evidence that he admitted purple-coloured flowers in *Pisum sativum*. The fact that the white-flowered pea, which was not known until the 13th century (a mutant, according to Lamprecht (1956)), is mentioned under *Pisum sativum* β in Sp. Pl., is further evidence that Linnaeus's circumscription of *P. sativum* is based mainly on the pre-Linnaean *P. arvense* sensu Bauhin a.o. As stated, the colour of the flower is not mentioned by Linnaeus, although included in the data provided by the earlier authors cited by him.

For the second *Pisum* species mentioned in Sp. Pl., *P. arvense*, Linnaeus gave the following analysis: '*Pisum* petiolis tetraphyllis, stipulis crenatis, pedunculis unifloris'. It is found not in, but between cereal fields ('habitat inter Europea segetes'). In Flora Suecica, 2nd ed. (1755), Stockholmiae: p. 250, Linnaeus added as a note to *Pisum arvense:* 'habitat in Westro gothiae agris inter segetes. Planta haec hodie apud nos rarissima est'. This species, therefore, is not considered by Linnaeus as a crop plant but as a weed or a wild growing species. All references to a cultivated species *P. arvense* L., frequently encountered in post-Linnaean literature up till now, are thus based on a misinterpretation of Linnaeus's *P. arvense.*

Possibly this Linnaean species does not hold anymore, since more wild species have been found and described, such as *P. elatius* Steven (1808), *P. jomardi* Schrank (1821), *P. fulvum* Sibthorn & Smith (1830), and *P. humile* Boisson & Noë (1856). It may be that these belong to Linnaeus's *P. arvense*, but this is mere speculation and falls outside the scope of this study.

(3) In Sp. Pl. (1753) Linnaeus refers under *P. arvense* to '*Pisum* pulchrum, folio

anguloso' of J. Bauhin and Morison. The first author cited by Linnaeus, Bauhin (in: Historiae plantarum universalis 2, Ebroduni, 1651: p. 297–298) gives the following information: this pretty pea is present in the hortus of Frederick Meyer; it is of Argentine origin and was collected by Mr. Agerius. The stems are more slender and delicate than those of the common pea; the stipules are rather similar to those of *Aphaces* of Dodonaeus, but more obtuse at top and angular at base, serrate as it seems; leaves 4-foliolate (2 jugae), rachis with a tendrilled top, leaflets smaller than those of the common pea and as a rule dented; racemes uni-flowered, flower small. Linnaeus cited as the second author Morison (1680; see Stearn, facs. ed. Linn. Sp. Pl., 1958, App.: p. 38). In his Historiae plantarum universalis oxoniensis 2, Oxonii, 1715: p. 47, sectio 2, § 1, tab. 1a, fig. 4 (which is not an exact reprint of Mor. hist. 2 of 1680)[20], Morison based '*Pisum* pulchrum Bauh.' on the description of J. Bauhin as cited above, which he largely copied, but additional information was provided: leaflets 2 or 3 jugae, flowers white or purple (cf. key, l.c. p. 46), pods smaller than those of the common pea, sometimes with a curved beak. Morison considered '*Pisum* leptolobum' of Camerarius teste Lobelius to be the same taxon. Bauhin's '*Pisum* pulchrum' contains *Pisum* types with or without a stiff pod wall ('sine cortice duriore') but the pod wall should be thin. The stiff-walled *Pisum* type was introduced by Camerarius from Vilda (Wilna) in Lithuaria.

(4) As a rule the following pod types are found within the cv.-group Sativum.
(a) Pods large to medium, broad, pod wall fleshy, with stiff papery inner parchment; mature pods with thin pod wall and small (WP 7754, WP 7787, WP 7819); dried seeds large, globose, white with orange tinge.
(b) Pods medium-sized to small, slender, pod wall fleshy, with stiff papery inner parchment; mature pods with thin pod wall and small; dried seeds small, as a rule globose, either white with orange tinge or coloured otherwise.

(5) Based on seed characteristics, Govorov (1930) distinguished 17 varieties of peas excluding cv.-group Abyssinicum. Within ssp. *arvense* proles *aethiopicum*, with standard light purple or pink and wings dark violet or purple, he gives 14 varieties, whereas within ssp. *sativum* proles *subaethiopicum*, with standard and wings white, he mentions three varieties. Later on, in 1937, Govorov brings all peas, except *abyssinicum*, under ssp. *commune* proles *aethiopicum*, with 14 varieties. These classifications are not practical, since they use small differences in delimiting the varieties.

(6) The following seed types have been observed in Ethiopia.
(a) Seeds large, globose, smooth, white with orange tinge. I designate this taxon as cv. White Adere (based on WP 3192A, WP 7817, WP 7818 and WP 7819). Pods large. Rare.
(b) Seeds smaller, globose, as a rule smooth, white with orange tinge or green. I designate this taxon as cv. Shashamane Ater (based on WP 2598, WP 7763, WP 7764 and WP 7765). Infrequent.

20. The 1680-edition, being present in the library of the British Museum (Dept. of Botany), appeared to be identical with the 1715-edition, for the pages concerned.

(c) Seeds smaller, globose, smooth or slightly wrinkled, orange-brown to brown (sometimes green-brown). I designate this taxon as cv. Addis Abeba (based on WP 3030, WP 7800, WP 7801 and WP 7802). Common.
(d) Seeds smaller, globose, slightly wrinkled, dark violet. I designate this taxon as cv. Violet Mariam (based on WP 2819A, WP 6659, WP 6660 and WP 6661). Rare.
(e) Seeds smaller, globose, smooth or slightly wrinkled, with violet spots; hilum sometimes black. I designate this taxon as cv. Speckled Shoa (based on WP 3026C, WP 7070, WP 7071 and WP 7072). Frequent.
(f) Seeds smaller, globose, smooth or slightly wrinkled, marbled. I designate this taxon as cv. Wolliso Marble (based on WP 3250D, WP 7823, WP 7824 and WP 7825A). Rare.

(a) and (b) give plants with white flowers, the others plants with purple flowers.

The most widespread types in Ethiopia are, according to Govorov (1930), purple-speckled, uniformly coloured brownish-grey with black and brown hilum, of angular and roundish-angular shape *(angulatum, angulare, asmaricum, concolor)*, and the white-flowered, yellow-grained forms.

(7) In general plants raised at Wageningen in the field were more vigorous, as (apart from differences in height) is apparent from the following

	Plants grown at Wageningen	Plants grown in Ethiopia
petiole	(3.5–) 5.0– 7.5 (–10.5) cm	(2.0–) 4.0–6.0 (–7.5) cm
leaflet: length	(2.5–) 3.5– 6.5 (– 8.0) cm	(1.5–) 2.5–5.0 (–6.0) cm
width	(1.5–) 2.0– 3.0 (– 4.0) cm	(1.0–) 1.5–2.5 (–3.0) cm
filiform apex	0 – 3 cm	0 –2 cm
peduncle	(2.5–) 4.0–12.0 (–22.0) cm	(1.5–) 3.5–7.0 (–9.5) cm
seed	6 –10 mm	6 –8 mm

(8) The description is based on the following specimens.

Eritrea	Adi Caier market: Sl 879.
Tigre	50 km past Adua on Adigrat road, in field: J. J. de Wilde 7050; Axum market: Sl 954; Adi Shoa market: Sl 1029.
Begemdir	Gondar market: WP 5002A–WP 5002E, WP 5003B–WP 5003D; Sl 912; Infranz market: Sl 831, Sl 838.
Gojam	Bahar Dar market: WP 4966A–WP 4966D; Upper Ghieleb (Godeb) valley, Choke Mts: Evans and Leaky 142 (K!); Telili market: Sl 807, Sl 808; Lumane market: Sl 746; Elias market: Sl 792; Dejen market: Sl 758.
Wollo	Bati market: WP 4017A–WP 4017C, Sl 1043; Kombolcha market: Sl 970; Dese market: Sl 1103; Haik market: Sl 1133; Woldya market: WP 4022A–WP 4022D.
Shoa	Addis Abeba market: WP 3026A–WP 3026C, WP 3027A–WP 3027C, WP 3028, WP 3029A–WP 3029D, WP 3030A–WP 3030C; Robi market: Sl 1154; Ghion market: WP 3248C–WP 3248E, WP 3249A–WP 3249D, WP 3250A–WP 3250D; Debre Zeit market: WP 2986A–WP 2986D, WP 2987A–WP 2987E, WP 4904A–WP 4904E; Nazret market: WP 3128A–WP 3128G; Butajira market: WP 3391A–WP 3391D, WP 3392A–WP 3392C; Kuyera market: Sl 1194, Sl 1195; Shashamane market: WP 2598A–

	WP 2598C, WP 2599A–WP 2599D; 4 km past Shashamane on Wondo valley road, in field: WP 2613.
Illubabor	Dembi market: WP 3357A–WP 3357E; Bedelle market: WP 5490A–5490E, WP 5491A–WP 5491E.
Kefa	Jima market: WP 3256A–WP 3256D, WP 3257A–WP 3257D, WP 3271A–WP 3271D, WP 3301A–WP 3301E, WP 3302A–WP 3302C, Sl 122, Sl 126, Sl 128B; Giren, in abandoned field of Jima Agric. School Farm: F. G. Meyer 7907 (K!); Agaro market: WP 3272A–WP 3272C, Sl 86, Sl 104; Bonga market: WP 3340A–WP 3340C; Woshi market: WP 8564A–WP 8564C, WP 8565A–WP 8565D, WP 8566A–WP 8566C.
Gamu Gofa	Giarso market: WP 3222A–WP 3222C; Doko valley, pasture and arable land: Mulvany 172 (K!).
Sidamo	Awasa market: WP 2715A–WP 2715E, WP 2846A–WP 2846E, WP 2847A–WP 2847E; Yirga Alem market: WP 2657A–WP 2657C, WP 2658A–WP 2658D, WP 2659A–WP 2659C; Dila market: WP 2818A–WP 2818B, WP 2819A–WP 2819G; Soddo market: WP 2948A–WP 2948C, WP 2949A–WP 2949D.
Bale	Habbe market: J. J. de Wilde 7369; Goba market: Sl 1224.
Arussi	40 km south of Nazret on Asella road, in field: WP 1536, WP 1537; Sire market: *Sl 159*; Asella market: *WP 2991C*$_1$, *WP 2992A–WP 2992C*.
Hararge	Assebot market: Sl 696; Asbe Teferi market: Sl 467–Sl 469; Bedessa market: WP 3177A–WP 3177D, Sl 668; Karra market: Sl 581; K'uni market: Sl 537; Moulou market: Sl 443; Gelemso market: Sl 617; 84 km past K'obo on Asbe Teferi road, in field: WP 2564, WP 2565; 3 km past Ch'elenko on Asbe Teferi road, in field: WP 1011; Ch'elenko market: Sl 270, Sl 277; 41 km past Langhe on Deder road: WP 2518, WP 2519; Deder market: Sl 386; Langhe market: Sl 297; Bedeno market: Sl 319, Sl 320; Wotter market: Sl 201; Dire Dawa market: WP 118A–WP 118D; Alemaya market: WP 7A, WP 15A–WP 15B, WP 17A–WP 17D, Sl 224; garden Alemaya: WP 212, WP 221, WP 222, WP 225–WP 227, WP 244–WP 246, WP 253–WP 255, WP 257–WP 258, WP 264–WP 265, WP 313–WP 314, WP 338–WP 339, WP 348–WP 349, WP 738, WP 757, WP 1057, WP 1060, WP 1064, WP 1075, WP 1078, WP 1188, WP 1191–WP 1194, WP 1197, WP 1782–WP 1783, WP 1796, WP 1821, WP 1825, WP 2177, WP 2184A–WP 2184C, WP 2197, WP 2200; Harar market: WP 38A–WP 38C, WP 43A–WP 43D, WP 44A, WP 45A–WP 45C, WP 50A–WP 50B, WP 101A–WP 101D, WP 107A–WP 107E, WP 3191A–WP 3191F, WP 3192A–WP 3192E; Feddis market: Sl 177; Jijiga market: WP 3494E.
Grown at Wageningen	WP 5596–WP 5597, WP 5628–WP 5636, WP 5643–WP 5654, WP 5714–WP 5722, WP 5744–WP 5752, WP 5759–WP 5764, WP 5786, WP 5947–WP 5951, WP 5993–WP 5998, WP 6038–WP 6044, WP 6205–WP 6206, WP 6219–WP 6221, WP 6248–WP 6250, WP 6255–WP 6257, WP 6365–WP 6368, WP 6404–WP 6407, WP 6485–WP 6488, WP 6493, WP 6508–WP 6536, WP 6553–WP 6566, WP 6653–WP 6679, WP 6705–WP 6730, WP 6791–WP 6808, WP 6841–WP 6866, WP 6871–WP 6873, WP 6875–WP 6883, WP 7064–WP 7104, WP 7723–WP 7725, WP 7737–WP 7738, WP 7753–WP 7887, WP 8689, WP 8693; Frahm-Leliveld 62344 from seeds obtained from Wonji (sheet with 1 element of cv.-group Abyssinicum and 4 elements of cv.-group Sativum (K!)).

Ecology

Peas require a cool, relatively humid climate with temperatures between 13 and 19 °C; so they seldom yield well in the tropics below 1200 m. In cooler climates they are cultivated as a summer annual, in warmer climates as a cold season annual. In subtropical areas with cool winters and not too high spring temperatures peas are sometimes grown as cold season crop. Hot dry weather interferes with seed setting. A reasonable level of soil fertility is required with a pH of 5.6–6.5; they do not tolerate very acid soils or water-logging (Purseglove, 1968; Whyte et al., 1953).

Stanton et al. (1966) refer to types commonly grown in Africa as short-day adapted cultivars which may be grown in the lowlands in the dry season, provided they are irrigated.

Husbandry

Peas mature in 3–5 months and yield between 500 and 1500 kg/ha. In south-west Uganda and Ruanda, grown mainly between 1800 and 2550 m, field peas provide the staple pulse of several tribes. In this area they are the first crop after a grass fallow or on land opened-up after grazing. Dwarf field cultivars are broadcast in the grass; the plot is then roughly hoed once, thus producing a very rough seedbed. No weeding or further cultivation is done and yet fair yields are obtained with a minimum of work. The plants are cut when mature and then dried and threshed (Purseglove, 1968).

In Ethiopia peas equal horse beans in importance, after chickpeas and lentils, with average yields of ca 920 kg/ha. This annual is sown at the beginning of the big rains in July and harvested 3–4 months later. In large areas of central and north Ethiopia it is grown, either in a rotation scheme after cereals, or on poor sometimes badly eroded soils where a fair crop still can be produced. After harvesting, all green material is removed from the fields (Huffnagel et al., 1961). Where soil fertility is too low for wheat or barley, field peas can still be cultivated. It is remarkable that even badly eroded soils may produce a reasonable crop and how peas stimulate the following crops (Agriculture of Ethiopia 1, 1954). On red soils in Begemdir, pea can precede as well as follow barley, whereas on black soils in Shoa it may succeed several years of wheat and preceed fallow. As a rule the crop is grown in monoculture, but in Begemdir it is sometimes found together with horse bean (Simoons, 1960), in Wollo and probably elsewhere as well. For the Yerer-Kereyu Highlands the cultivation of pea is reported during April–July (Kuls, 1957).

In the Chercher Highlands peas are a minor legume like chickpeas. Here field peas are considered by the Galla as the best crop to sow the first year on fallow land cleared for sorghum or maize production. Peas are planted in July and harvested in late October. The pod stalks are separated from the plant before the pods have fully ripened, stacked in the field, covered with grass, and allowed to dry for 3–4 weeks before separation by trampling with livestock (Brooke, 1958).

In Sidamo peas, together with horse beans, wheat and barley, constitute the cereal-

pulse zone between ca 2200–2400 m (Kuls, 1958); this holds as well for other highland regions.

Uses

Peas may be divided into several groups according to their use.
(a) Forage, green manure and soil cover
(b) Dry, edible seeds
(c) Green shelling peas
(d) Canning peas
(e) Edible pods, if there exists no lining membrane in the young pods (Whyte et al., 1953).

Fresh green seeds are cooked and eaten as a vegetable; they are also canned and frozen. Pods and seeds of some cultivars are eaten. Ripe dried seeds, either whole, split, or as flour, are used for human and stock food. Although from the very early days dried peas were known in Europe, green peas were not used until the 16th century. In Burma and parts of Africa leaves are used as a pot herb. Plants and haulms are suitable as forage, hay, silage and green manure (Purseglove, 1968).

The various types of Ethiopian field peas are fairly sweet and edible. They are eaten both fresh and dried. In the latter case they are usually finely ground to make 'wot". The fresh green peas can be eaten raw. The dried vines give a good livestock feed.

Protein content

Young pods: 2.6–3.1% (Terra, 1966); young green seeds: 3.1–7.2% (Terra, 1966); ripe seeds: 22.5% (Darby et al., 1959), ca 22% (Terra, 1966).

The first limiting amino acids are methionine and cystine, followed by tryptophan (Aykroyd & Doughty, 1964).

(12) Psophocarpus palustris Desv. **Fig. 23**

'*Psophocarpus*': from 'psophos' (Greek: sudden sound), and 'karpos' (Greek: fruit); the ripe pod dehisces with a crack.
'*palustris*': marshy, growing in marshes (derived from 'palus' (Lat.): marsh).

Desveaux, Annls Sc. Nat. Sér. 1, 9: p. 420 (1826).
Type: locus humidus Senegaliae; Desveaux (P, holo.!).

Synonyms

Dolichos suffultus Grah., in: Wall., Cat. no. 5564 (1828).
Psophocarpus palmettorum Guill. & Perr., Florae Senegambiae Tent. 1: p. 222 (1830).
Diesingia scandens Endl., Flora 15(1): p. 117 (1832).
Psophocarpus longepedunculatus Hassk., Flora 25(2), Beibl.: p. 51, 75 (1842); Pl. Hort. Bog.: p. 280 (1844).
Botor palustris O. Kuntze, Revis. 1: p. 163 (1891).

Literature

1859: Bentham, in: Martius, Flora Brasiliensis 15(1): p. 197-198. (tax.)
1871: Baker, in: Oliver, Flora Trop. Africa 2: p. 208-209. (tax.)
1879: Baker, in: Hooker, Flora British India 2: p. 211-212. (tax.)
1927: Heyne, Nuttige planten van Ned. Indië 2: p. 849. (agric.)
1937: Dalziel, Useful plants of West Trop. Africa: p. 256. (tax.)
1954: Wilczek, Flore Congo Belge 6: p. 283-285. (tax.)
1955: Cufodontis, Enumeratio, Bull. Jard. bot. État Brux. 25(3): p. 343. (tax.)
1963: Backer & Bakhuizen van den Brink, Flora of Java 1: p. 644-645. (tax.)
1963: Cobley, An introduction to the botany of tropical crops: p. 153-154. (agric.)
1964: Aykroyd & Doughty, Legumes in human nutrition: p. 110-111. (agric.)
1966: Burkill, Dict. ec. prod. Malay Peninsula 2: p. 1850-1851. (agric.)
1966: Terra, Tropical vegetables: p. 61. (agric.)
1968: Purseglove, Tropical Crops, Dicotyl. 1: p. 315-316, 318. (agric.)
1968: Verdcourt, Taxon 17(5): p. 538-539. (tax.)
1971: Verdcourt, in: Flora of Trop. East Africa, Leg. 4, Papil. 2: p. 603-604. (tax.)

Local names:?
Trade names:?

Geographic distribution

Psophocarpus palustris grows wild throughout tropical Africa. Although Burkill (1966) mentions that it is widely cultivated in tropical Africa, Dalziel (1937), however, says that there is no certain record of its cultivation in West tropical Africa, although it is apparently indigenous there. Purseglove (1968) has recorded occasional cultivation in Africa, e.g. on coral rag in Zanzibar.

In Ethiopia it is an almost unknown crop and only found once as such by the author.

A potentially more important food plant in *Psophocarpus* Neck. ex DC. is *P. tetragonolobus* (L.) DC., the Goa bean. It probably originated in tropical Asia, where it is now mainly cultivated. There it was first recorded by Rumphius in the Moluccas (Herb. Amb. 5: p. 374, t. 133 (1747)), who supposes that it was brought from elsewhere, probably from Bali or from Java. Burkill (1966) thinks that the Goa bean originated on the African side of the Indian Ocean (Madagascar, Mauritius?), but its earlier history is lost. However, it is unimportant on the African mainland. According to Purseglove (1968) *P. tetragonolobus* seems to have been long known to the Melanesians and is fairly extensively cultivated in New Guinea. It has been introduced into the West Indies.

Description

A climbing, (slightly) pubescent perennial, usually grown as an annual. Roots becoming thick and tuberous (not seen in Ethiopian specimen, since underground parts were not collected).

Stems angled, (ridged), sometimes laterally compressed and twisted, pubescent with

long, white–brownish, appressed hairs.

Stipulae ovate, spurred, together with the spur ca 1.5 cm long, dark blotched (when dry), (slightly) pubescent with brownish hairs.

Leaves alternate, 3-foliolate. Petiole ca 5–10 cm long, angled, slightly grooved above, (slightly) pubescent, pulvinus more densely pubescent. Rachis ca 2–3 cm long, grooved above, sparsely pubescent, topped by a leaflet.

Leaflets: First two leaflets opposite and asymmetrical, top leaflet symmetrical, ca 6–10 × ca 4–8 cm, short-petioluled with indumentum denser than on petiole, ovate, top leaflet sometimes shallowly laterally lobed at base, entire, truncate at base, acuminate at top, dark green above, glabrous, with veins and edge of leaflets thinly pubescent, grey-green below and venation more prominent.

Stipellae variable in shape, as a rule narrowly ovate, ca 0.5 cm long, slightly pubescent, at the base of the petiolule, 1 per lateral leaflet, 2 per top leaflet.

Inflorescence a many-flowered axillary raceme. Peduncle ca 2–15 cm long, laterally compressed, slightly twisted, pubescent towards the top. Rachis ca 5–16 cm long, laterally compressed, slightly twisted, tubercled, pubescent, with indumentum denser towards the top; flowers with a fleshy, more or less swollen, disk-shaped receptacle, arising 1–3 together from tubercles on rachis; tubercles subtended by a deciduous, irregularly shaped, leaf-like bract, ca 5 mm long, sometimes with ca 3 acuminate teeth, (slightly) pubescent. Bracts 1 per flower, deciduous, ovate, ca 5 mm long, slightly pubescent. Pedicels short, ca 5–12 mm long, frequently laterally compressed, pubescent, with two bracteoles attached at base of calyx. Bracteoles prominent, persistent, (broadly) ovate, ca 5–10 mm long, ± fleshy, at base often ± auricled, with some low, smooth, longitudinal ridges, slightly pubescent.

Calyx campanulate, (slightly) pubescent; tube ca 8 mm long; lobes 5, the upper part of lobes connate, forming an emarginate lip, the other three lobes subequal with the lower most lobe longest, triangular, acute at top, ca 3–7 mm long.

Corolla with standard erect, (always?) reflexed, broadly elliptic, ca 3.0–3.7 × 2.5–3.7 cm, clawed, bi-auriculate, with auricles partly incurved and gradually forming an appendage (the two appendages hinge to the auricles of the wings), emarginate at top, delicately papillate on both surfaces, light green abaxially, pale blue-violet adaxially with a green-yellowish spot running from above the claw to the centre of the petal. Wings obovate, ca 3.0–3.7 × ca 1.0–1.7 cm, clawed, prominently auriculate, rounded at top, glabrous, with tip of auricle papillate adaxially, pale blue-violet. Keel very shallowly obtriangular, ca 3.0–3.7 × ca 1.5 cm, clawed, auriculate, entirely split dorsally, ventrally split near the base, left and right with a small 'pocket', a longitudinal fold, and below this an area of minute foldlets perpendicular to the lower edge, rounded at top, white to pale blue.

Androecium: Stamens diadelphous (9+1). Vexillary stamen ca 2.8 cm long, slightly flattened and geniculate near the base, the upper third upturned, cohering above its base with other stamens, but easily separating. Staminal sheath ca 1.5 cm long when on either side the first filament is released; this is generally followed by 3 single stamens after which finally the top stamen is released; free part of filaments ca 1.8 cm

long, slightly laterally compressed, upturned. Anthers globular, ca 1 mm long, basi-dorsifixed, light brown.

Disk annular, ribbed, wavy.

Gynoecium: Ovary sessile, ca 2 cm long, laterally compressed; wings inconspicuous; apical part sterile; at base papillulate, otherwise glabrous; ca 5–8-ovulate. Style upturned, ca 2 cm long, flattening towards the base, bent at top and flattened, giving the appearance of a swan's head, with a conspicuous tuft of long, moniliform, brownish hairs adaxially below the stigma, otherwise glabrous. Stigma terminal, glandular-papillate, surrounded at base by shorter hairs.

Pod oblong, square in transverse section, ca 7–10 × ca 1.5 cm, with a long subulate curved, deciduous beak, distinctly 4-winged along the angles, with wings erose, slightly short-pubescent, chambered (fleshy septs between the seeds), 4–8-seeded.

Seeds: Young seeds ellipsoid–subcylindrical, slightly compressed, but generally more rounded, 7–8 × 5–6 mm, brown. Hilum elliptic. Mature dry seeds not available for description.

Seedling: not available.

Note

The description is based on one sample only.

Taxonomic notes

(1) Desveaux collected and described (1826) from Senegaliae *Psophocarpus palustris*. The original specimen is kept in Paris, which is the holotype. The specimen collected in Ethiopia is designated to belong to cv. Wondo Surprise (based on WP 2666).

(2) *Psophocarpus* Neck. ex DC. is a small genus comprising about 10 species in the tropics of the Old World; one species naturalized in tropical America. *P. tetragonolobus* (L.) DC. is a well-known vegetable in south-eastern Asia, where it is grown for local consumption, but apparently it has been scarcely tried in Africa up till now. It has never been recorded for Ethiopia, as far as I know. It is somewhat similar to *P. palustris* but has shorter inflorescences, bracteoles which are much shorter than the calyx, larger flowers (up to 3 cm) with wings having on the upper side near the claw a T-shaped appendage (see Bentham, 1859; Backer & Bakhuizen van den Brink, 1963), much longer fruits (up to 40 cm), many-seeded (8–21), and $2n=26$, whereas for *P. palustris* $2n=20$ and 22 have been recorded. According to Backer & Bakhuizen van den Brink (1963), the lower surface of the leaflets is studded with minute glandular dots, but this has not been confirmed by others. Baker (1871) records a type with white flowers and silky bracteoles which are shorter than the calyx (*P. longepedunculatus* Hassk. var. *barteri* Baker), collected by Barter in Upper Guinea.

(3) *Psophocarpus palustris* is supposedly found in Ethiopia (Wilczek, 1954), but Cufodontis (1955) doubts whether this is correct. Since Wilczek did not specify his information, it is impossible to check it. As far as I know the specimen collected in

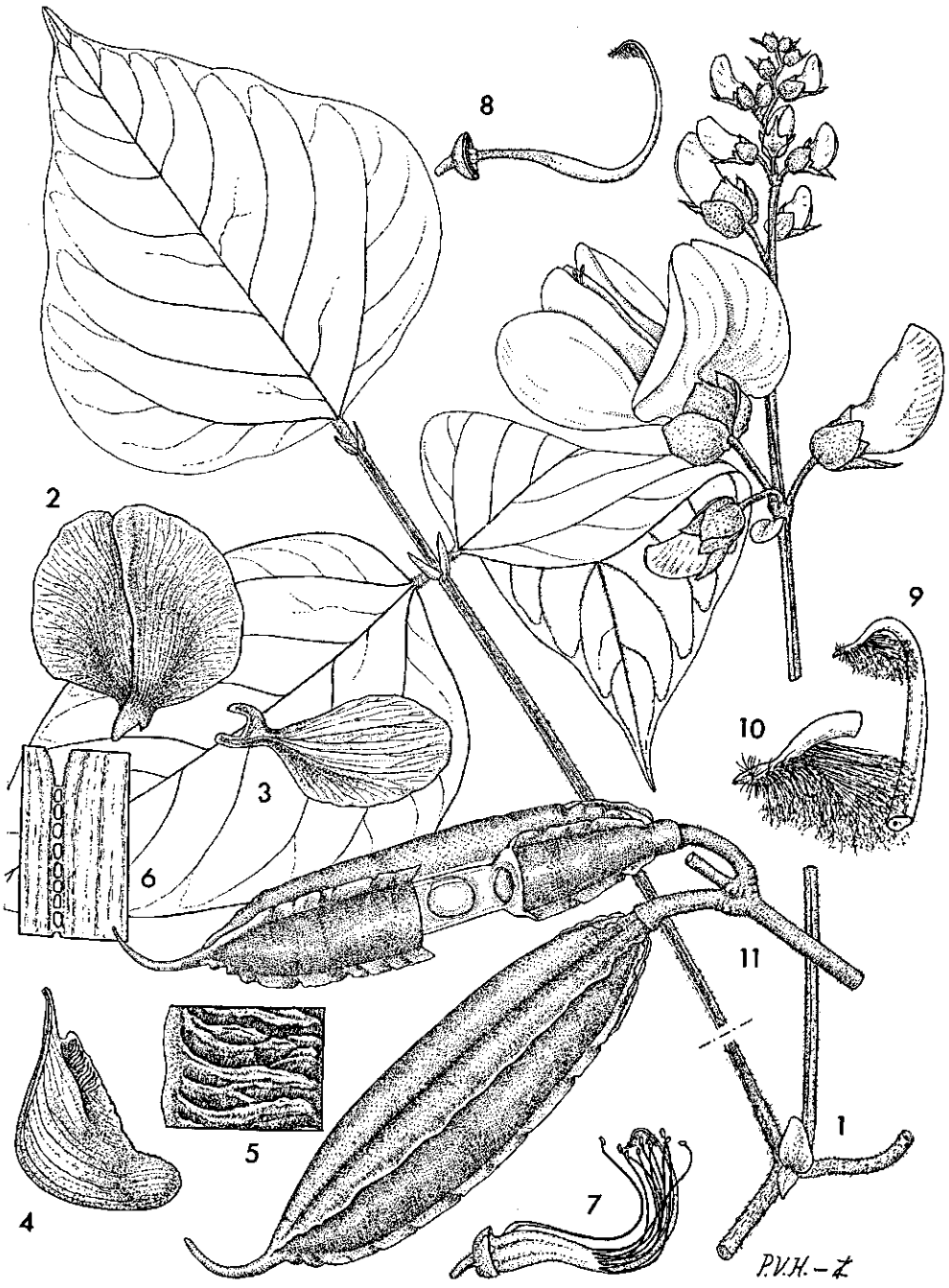


Fig. 23. *Psophocarpus palustris* Desv. cv. Wondo Surprise. – 1. branch with leaf and inflorescence (5/6×); 2. standard, abaxial view (5/6×); 3. wing, abaxial view (5/6×); 4. keel (5/6×); 5. detail of foldlets of the keel (5×); 6. detail of the connate ventral edges of the keel (5×); 7. staminal sheath + pistil (5/6×); 8. pistil + disk (5/6×); 9. style + stigma (2½×); 10. stigma, side view (5×); 11. pods (5/6×). – 1. WP 2666; 2–11. WP 2666 (spirit mat.).

1967 by the author is the first recorded in Ethiopia. It has flowers equalling in size those of *P. tetragonolobus*, but in other respects closely resembles *P. palustris*.

(4) *Psophocarpus palustris* is treated in recent flora's dealing with tropical Africa as a species with a range throughout the area from West to East. It became clear to Verdcourt (1968) that the West African populations were different from those occurring elsewhere in a number of admittedly small characteristics: the bracteoles are mostly much shorter than the calyx tube and nearly always densely pubescent, the wings are broader and more curved, the leaflets are less regularly triangular and sparsely to densely pubescent or hairy beneath, and the pods are shorter and nearly always (3–)4(–5)-seeded. The other populations have glabrescent or glabrous bracteoles equalling or exceeding the calyx, wings narrower and straighter with the narrowest portion longer, leaflets more regularly triangular, truncate at base and almost to quite glabrous beneath and (4–)6–8-seeded pods. There is no doubt, according to Verdcourt, that there are two distinct taxa which need a name at some level, and he considers them to be distinct species: *P. palustris* Desv. (West Africa from Senegal to Cameroon) and *P. scandens* (Endl.) Verdc. (Africa from Cameroon, Zaire and Angola to the Sudan, East and south-east Africa, cultivated in south-east Asia and Brasil). This seems a rather premature conclusion, since no revision of the genus *Psophocarpus* as a whole is available. Moreover, since only 'a number of admittedly small characters' is involved of which the shape of the leaflets and the pubescence of bracts/bracteoles and leaflets are variable characteristics even on the same plant, the new names only tend to enlarge the confusion in the genus. A revision of the genus *Psophocarpus* Neck. ex DC. is therefore most desirable.

(5) Seeds of *P. palustris* and *P. tetragonolobus* from the seed collection of the Department of Tropical Crops were sown in the greenhouse at Wageningen. The seedlings showed hypogeal germination.

(6) The description is based on the following specimen.

Sidamo In garden, 1 km past Wondo on Agere Selam road: WP 2666.

Ecology

Wilzcek (in: Flore Congo Belge: p. 285 (1954)) describes the habitat of *P. palustris* as follows: 'savanes herbeuses, savanes à *Pennisetum*, forêts ripicoles périodiquement inondées, galeries forestières, bords des marais, jachères, cultures abandonnées'[21]. Hepper (in: Flora West Tropical Africa 2nd ed: p. 572 (1958)) mentions that it is 'climbing on trees in swampy places'. Verdcourt (1971) specifies its habitat as follows: 'swamps, streamsides, ponds in forest areas, often rooting in the water, also in disturbed grasslands and cultivations; 0–810 m'.

It is clear that *P. palustris* is a plant preferring a humid habitat.

21. Grass savannas, *Pennisetum* savannas, periodically inundated riverine forests, gallery forests, swamp fringes, fallows and abandoned cultivated fields.

In Ethiopia the author once found it as a garden crop growing in a fence at ± 1850 m in a region with over 1500 mm rain annually.

Husbandry

No information is available.

Uses

The young leaves and young pods are eaten as a vegetable. The tuberous roots are also edible (Aykroyd & Doughty, 1964; Dalziel, 1937; Wilczek, 1954). According to Heyne (1927), Hasskarl stated that the ripe seeds are used in Indonesia in the same way as those of *P. tetragonolobus*, being consumed after parching. It is also suitable as a cover crop.

In Ethiopia the use of this plant is unknown to the people.

As a crop it is less important than the Goa or asparagus bean, *Psophocarpus tetragonolobus*, from which several uses are known: the young leaves, young shoots and young pods are eaten either raw or steamed, the immature pods may be cut-up and cooked in the manner of French beans, flowers and flower buds are also edible, the ripe roasted seeds are usually eaten with rice. On Java the ripe seeds serve as a food after parching. In some areas, the tuberous roots are consumed, raw or cooked, notably in Burma (when raw they are slightly sweet, and firm as an apple). It has been suggested to use the plant as a green manure or cover crop, for fodder and as a restaurative fallow crop, because of its exceptional nodulation (Burkill, 1966; Purseglove, 1968).

In Ethiopia *P. tetragonolobus* has not been encountered yet.

Protein content

Nowhere reported.

(13) Trigonella foenum-graecum L. (2n = 16) Fig. 24; Plates 60–61

'*Trigonella*': based on Greek 'trigonos', meaning triangle or triangular. The suffix 'ella' suggests small proportions. It seems that the small flowers of *T.* are more or less triangular in outline.
'*foenum-graecum*': Lat.: foenum = hay; graecum = greek. In past centuries this plant, common in southern Europe, was widely used as a fragrant herb against many complaints.

Linnaeus, Sp. Pl. ed. 1: p. 777-778 (1753).
Type: from France (Montpellier); '*Trigonella* leguminibus sessilibus strictis erectiusculis subfalcatis acuminatis' (LINN, specimen 932.16, lecto.!).

Synonyms

Buceras foenum-graecum All., in: Fl. Pedem. 1: p. 313 (1785).
Foenum-graecum sativum Med., Vorles. Churpf. Phys. Ges. 2: p. 383 (1787).

Foenum-graecum officinale Moench, Meth.: p. 142 (1794). (*Foenugraecum officinale*, in: Alef., Landw. Fl.: p. 71 (1866)).
Foenugraecum officinale var. *cultum* Alef., Landw. Fl.: p. 71 (1866).
Telis foenum-graecum (L.) O. Kuntze, Rev. 1: p. 209 (1891).
Trigonella foenum-graecum ssp. *culta* (Alef.) Gams, in: Hegi, Illustr. Fl. Mittel-Europa 4(3): p. 1232 (1924).

Literature

1924: Gams, in: Hegi, Illustr. Flora 4(3): p. 1231-1232. (tax. + agric.)
1953: Whyte et al., Legumes in agriculture: p. 338-339. (agric.)
1955: Cufodontis, Enumeratio, Bull. Jard. bot. État Brux. 25(2): p. 244. (tax.)
1958: Brooke, Econ. Bot. 12: p. 203. (agric.)
1963: Cobley, An introduction to the botany of tropical crops: p. 219-220. (tax. + agric.)
1963: Rouk & Hailu Mengesha, I.E.C.A.M.A. Exp. Stn Bull. 20: p. 2-6. (agric.)
1963: Siegenthaler, I.E.C.A.M.A. Exp. Stn Bull. 14: p. 4. (agric.)
1965: Beyene Chichaibelu, Unpubl. Master's Thesis, Cornell Un. (partly agric.)
1966: Burkill, Dict. ec. prod. Malay Peninsula 2: p. 2221-2222. (agric.)
1968: Purseglove, Tropical Crops, Dicotyl. 1: p. 217. (agric.)

Local names: abish (Amarinia); abacha, abakte (Tigrinia); ulbata, sunqo, sunk'o (Gallinia); sunk'o, shuk'o, shumfa (Arussi, Guji); fit'o, fet'o (Borana); graro (Kaffinia).
Trade names: fenugreek (English); fénugrec (French).

Geographic distribution

Native of southern Europe and Asia the cultivation of fenugreek now extends from the Mediterranean to western India and China, south as far as Ethiopia and is found in the U.S.A. as well (especially California). The plant is mainly used locally for a variety of purposes. It is grown in Egypt and in the Sudan under irrigation and has been introduced into various parts of the tropics, but it only attains any importance in India, northern Africa and Ethiopia. The main producing areas are India, Ethiopia and Turkey. In Europe where fenugreek was cultivated in ancient times as a fodder, it has been replaced by more productive fodder crops, and also the use for medicinal purposes has declined (Burkill, 1966; Cobley, 1963; Purseglove, 1968).

It is found in nearly every Ethiopian market.

Description

An erect, stiff, highly aromatic annual. Taproot well-developed; roots much branching, sometimes lobed nodules present on the laterals (not seen on specimens collected in Ethiopia).

Stems terete, slightly pubescent, internodes of older stems hollow, with several well-developed basal branches, green to purple.

Stipulae small, partly or sometimes almost entirely adnate to the petiole, oblong to obliquely triangular, acute at top.

Leaves alternate, 3-foliolate. Petiole grooved above, sometimes slightly winged,

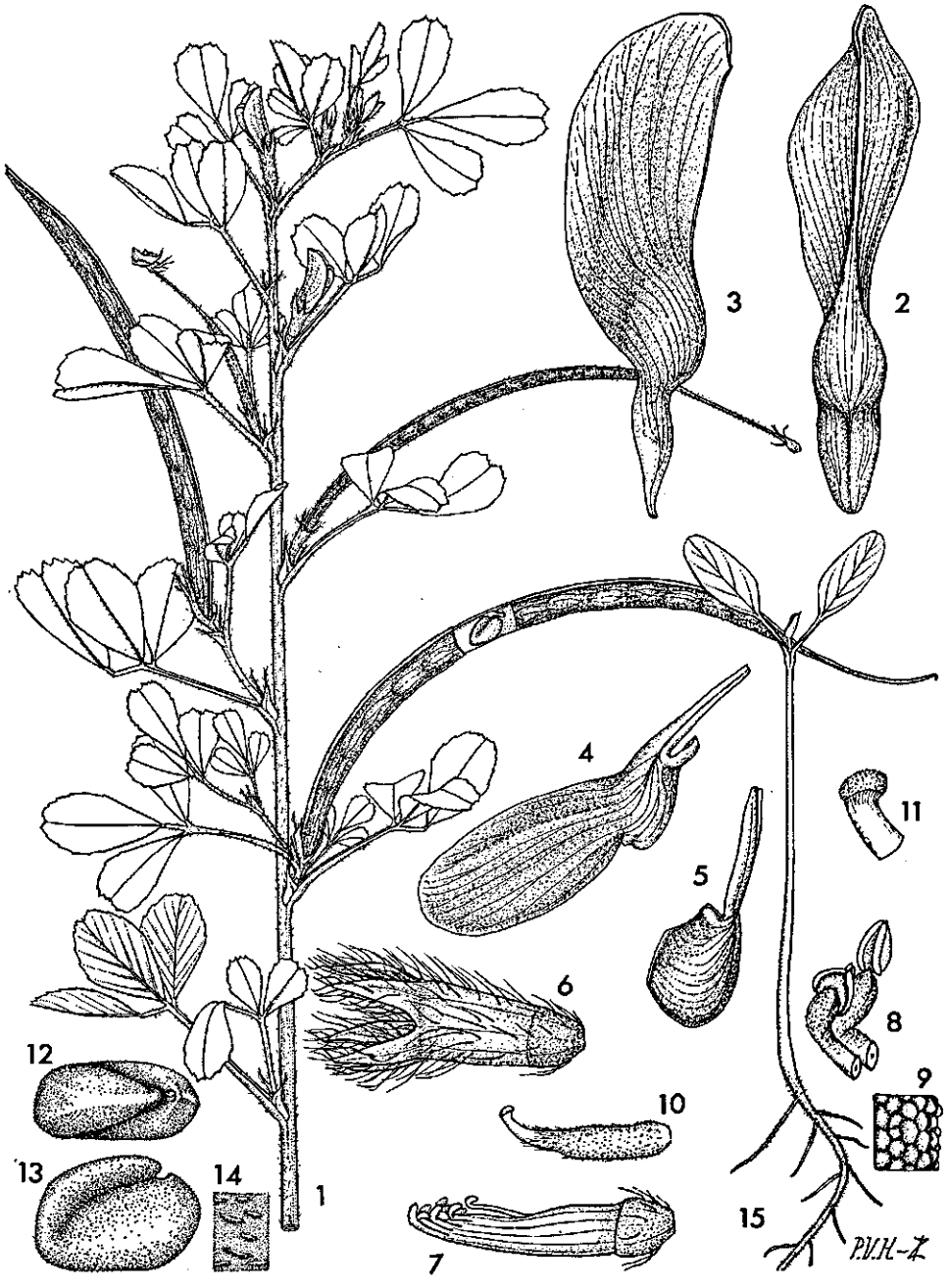


Fig. 24. *Trigonella foenum-graecum* L. cv. Bedelle Perfume. – 1. branch with leaves, inflorescences and pods ($^5/_6\times$); 2. standard, abaxial view ($5\times$); 3. standard, side view ($5\times$); 4. wing, abaxial view ($5\times$); 5. keel ($5\times$); 6. calyx ($5\times$); 7. staminal sheath ($5\times$); 8. anthers ($15\times$); 9. detail of papillate top part of filament ($100\times$); 10. pistil ($5\times$); 11. stigma ($15\times$); 12. seed, with hilum ($5\times$); 13. seed, lateral view ($5\times$); 14. detail seed coat ($25\times$); 15. seedling ($^5/_6\times$). – 1. WP 7589, WP 7590 (including spirit mat.); 2–11. WP 7591 (spirit mat.); 12–14. WP 3296A; 15. WP 7588 (spirit mat.).

(1.0–)1.5–4.0(–6.0) cm long. Rachis short, flat, topped by a leaflet.

Leaflets: First two leaflets opposite and asymmetrical, top leaflet symmetrical and slightly longer, shortly petioluled, (sometimes broadly) obovate, (1.3–)1.8–3.0(–3.8) × (0.5–)0.8–1.2(–1.7) cm, tapering towards the base, with edge smooth at lower part, as a rule dentate at upper part, obcordate to rounded and mucronate at top, almost glabrous.

Stipellae absent.

Inflorescence a single (or rarely paired) axillary, short-pedicelled flower. Bracts absent.

Calyx campanulate, finely pubescent; tube ca 4.5 mm long; lobes 5, subequal, ca 2 mm long.

Corolla with standard approaching the keel, hood-shaped, obovate, (11–)15 × (5.5–)7 mm, clawed, obcordate at top, with left and right an oblique ridge in the lower half, pale yellow. Wings obovate, ca 12 × ca 2.5 mm, clawed, auriculate, rounded at top, pale yellow, adherent to the keel. Keel ladle-shaped, ca 7 × ca 2 mm, clawed, entirely split dorsally, ventrally split near the base, bi-auriculate, pale yellow to white.

Androecium: Stamens diadelphous (9+1). Vexillary stamen free, ca 5 mm long, winged, slightly tapering towards the base. Staminal sheath ca 5 mm long; free part of filaments irregularly released, becoming winged and papillate towards the tip which abruptly narrows to a small papilla bearing the anther, ca 1–2 mm long. Anthers alternately basi- and dorsifixed, ca 0.5 mm in diam., pale yellow.

Disk absent.

Gynoecium: Ovary sessile, ca 5 mm long, pubescent, ca 12-ovulate. Style glabrous, ca 1.5 mm long. Stigma: the swollen, glandular-papillate ending of the style.

Pod linear, longitudinally and reticulately veined, slightly bulging over the seeds, (8.0–)12.0–15.0(–19.0) cm × 2–4 mm, widest at base, conspicuously long-beaked, (7–)10–15(–18)-seeded.

Seeds irregularly shaped, longer than wide, laterally compressed, obliquely furrowed on each side near the edge, giving the seeds a hooked appearance, ca 5 × 3 mm, as a rule greenish-brown, dark brown, rarely either whitish, greyish, or violet-speckled; surface as a rule smooth, sometimes wrinkled. Hilum round or elliptic. Cotyledons green.

Seedling with epigeal germination. Cotyledons elliptic, asymmetrical, (10–)15–20 (–30) × (5–)7(–12) mm, rounded at top; petiole winged. Epicotyl green, frequently purplish. First leaf simple, circular–elliptic, entire or sparsely subdenticulate; top mucronate, sometimes slightly emarginate; petiole grooved above. Second leaf as a rule 3-foliolate.

Taxonomic notes

(1) In LINN one sheet is present (932.16) with a specimen carrying mature fruits with the reference by number to Sp. Pl. ed. 1. It seems preferable to adopt this specimen (LINN, specimen 932.16) as the lectotype of *Trigonella foenum-graecum* L.

(2) The following seed types have been observed in Ethiopia.

(a) Seeds green-brown. I designate this taxon as cv. Bedelle Perfume (based on WP 5483, WP 7596, WP 7597 and WP 7598).

(b) Seeds white. I designate this taxon as cv. Aduan Victory (based on WP 4974, WP 7593, WP 7594 and WP 7595).

(c) Seeds grey. I designate this taxon as cv. Kolito Abish (based on WP 2862B, WP 6749, WP 7584 and WP 7585).

(d) Seeds dark brown. I designate this taxon as cv. Debre Birhan (based on WP 5564A, WP 7599, WP 7600 and WP 7601).

(e) Seeds violet-speckled. I designate this taxon as cv. Royal Gondar (based on WP 4982C).

(3) The description is based on the following specimens.

Eritrea	Adi Caier market: Sl 894, Sl 897.
Tigre	Adua market: WP 4974.
Begemdir	Gondar market: WP 4982A–WP 4982C, Sl 857, Sl 867, Sl 868; Infranz market: Sl 830, Sl 837.
Wollo	Kombolcha market: Sl 960, Sl 992–Sl 995; Bati market: Sl 1040; Dese market: Sl 1092; Haik market: Sl 1129, Sl 1130.
Gojam	Dejen market: Sl 773; Lumane market: Sl 733; Elias market: Sl 795, Sl 800.
Shoa	Debre Birhan market: WP 5564A–WP 5564B; 19 km past Nazret on Mojo road, in field: WP 1928; Kolito market: WP 2862A–WP 2862B, WP 2863; Kuyera market: Sl 1203.
Illubabor	Bedelle market: WP 5483.
Kefa	Jima market: WP 3296A–WP 3296C; Agaro market: Sl 78, Sl 80; Maji market: WP 8563.
Sidamo	Just east of Negelli, in field: J. J. de Wilde 6021.
Bale	Goba market: Sl 1220.
Arussi	Sire market: Sl 152.
Hararge	Assebot market: Sl 699, Sl 700; Asbe Teferi market: Sl 463; Bedessa market: Sl 669, Sl 670; Karra market: Sl 582, Sl 583; K'uni market: Sl 538–Sl 540; Moulou market: Sl 445, Sl 446; Gelemso market: Sl 624, Sl 625; Waichu market: Sl 508, Sl 509; 3 km past Ch'elenko on Asbe Teferi road, in field: WP 1014; Ch'elenko market: Sl 248; Deder market: Sl 391, Sl 392; Wotter market: Sl 209, Sl 210, Sl 214; Bedeno market: Sl 317, Sl 318; Langhe market: Sl 298; Dire Dawa market: WP 136; Alemaya market: WP 9, Sl 17, Sl 222, Sl 235; 2 km from College on Kombolcha road, in field: WP 523; garden Alemaya: WP 216, WP 273, WP 365, WP 727, WP 743, WP 765, WP 1055, WP 1065, WP 1080, WP 1779, WP 1835, WP 2180; Harar market: WP 57; Feddis market: Sl 178; Jijiga market: Sl 339, Sl 357; foot hills of Gara Muletta Mts, in field: J. J. de Wilde 5822.
Grown at Wageningen	WP 5604–WP 5608, WP 5810–WP 5814, WP 6094–WP 6097, WP 6212–WP 6213, WP 6748–WP 6751, WP 7584–WP 7604.

Ecology

Fenugreek is normally grown as a cool season annual in regions with a hot 'summer' and a mild or cool 'winter'. In India it is usually a cold season crop cultivated with or without irrigation. In the Sudan it is grown in small patches under irrigation as a

cool season crop (Whyte et al., 1953).

In Ethiopia it is found between ± 1800 and ± 2200 m, and is generally sown during the main rainy season of July–September.

Husbandry

It is either sown in 'spring' or in 'autumn', depending on the climate. In India it is sown in June or July, and it ripens in 2½–3 months (Whyte et al., 1953).

In Ethiopia it is a garden as well as a field crop (Siegenthaler, 1963 ?). In the latter case it occurs only on small patches at field borders. In the Chercher Highlands fenugreek is sometimes planted in garden plots but more commonly at the border of a sorghum and maize field. Sowing here takes place in July and by November the crop is ready for harvest (Brooke, 1958). In the highland of Wollo patches with flowering fenugreek have been observed in April.

Uses

Since ancient times fenugreek has been cultivated for food, fodder, medicinal purposes, as a spice, an insect repellent, and for religious rites. The Egyptians recognized it as a health giving plant and used it as a medicine, for food and in religious ceremonies. In Europe, fenugreek has long been considered good forage for livestock, but in modern times other forages have replaced it. In India, it was highly esteemed in ancient times both for food and as a medicine (Aykroyd & Doughty, 1964; Burkill, 1966; Gams, in: Hegi, 1924).

The seeds are very aromatic and contain trigonelline (which is not poisonous according to Burkill (1966)) and choline. The flavour of the seed is due to an essential oil containing coumarin. Beyene Chichaibelu (1965), however, reports that feeding fenugreek forage to cattle and sheep has been associated with lameness, caused by skeletal and cardiac muscular degeneration.

The plant is grown as fodder in parts of India. The seed is used as cattle feed, in curry powders, as a condiment, and has many uses in local medicine, but it is rarely eaten as a pulse. A yellow dye is extracted from the seeds. The leaves and young pods are eaten as a vegetable (Aykroyd & Doughty, 1964; Cobley, 1963; Terra, 1966). Burkill (1966) mentions that very young leaves are used in India and the Mediterranean in food, not as a flavouring (as they are very bitter) but because they are considered salutary. In the Sudan and Egypt various beverages are prepared from the seeds serving as a relief to stomach disorders. Throughout north Africa they serve to flavour food as condiments. They are applied in preparing imitation maple extract and mango chutney. Harem women of the East consume the seed to acquire a pleasing plumpness (Cobley, 1963; Purseglove, 1968).

In Ethiopia the following uses of fenugreek have been reported.

(a) Seeds are prepared alone (for fast 'wot") or with other spices in seasoning 'wot", for which purpose they are usually heavily roasted on the 'mitad' (grill), finely ground

and sprinkled into the 'wot".
(b) Flour is used to flavour 'injera' (pancake-like bread usually made of t'ef flour) and 'dabo' (loaf bread usually made of wheat flour).
(c) In combination with other spices it is used (as flour) to preserve and flavour butter.
(d) A beverage is prepared by soaking the seeds in water until germination starts. It is then thoroughly dried in the sun, ground and again soaked in water. The water is poured off, the dough (which has then lost its bitter taste) is mixed with honey or sugar and water to serve as a drink highly recommended for underweight persons and as an appetizer.
(e) Seeds boiled in water give a milk substitute for 2–4 month old babies.
(f) The seed is considered a very good body conditioner, but may have a diarrhoeic effect. It is considered the best treatment for rheumatism (Siegenthaler, 1963 ?).

Since fenugreek contains a reasonable quantity of essential amino acids (including lysine), and t'ef is deficient in lysine, Beyene Chichaibelu (1965) has suggested to supplement the t'ef diet with fenugreek.

Protein content

Leaves: 4.4–4.9% (Terra, 1966); ripe seeds: 27.4% (Darby, 1959).

(14) Vicia faba L.

Figs 25, 26; Plates 62–65

'*Vicia*': ancient Latin name for a plant of uncertain identity.
'*faba*': ancient Latin name for a bean.

Linnaeus, Sp. Pl. ed. 1: p. 737 (1753).
Type: sine loco; '*Vicia* caule erecto, petiolis absque cirrhis' (LINN, specimen 906.34, lecto.!).

Synonyms

Faba bona et *Faba equina* Med., Vorles. Churpf. Ges. 2: p. 360 (1787).
Faba vulgaris Moench, Meth.: p. 150 (1794).

Literature

1924: Gams, in: Hegi, Illustr. Flora 4(3): p. 1556-1560. (agric.)
1931: Muratova, Bull. appl. Bot. Genet. Pl. Breed., Suppl. 50: p. 248-285. (tax.)
1955: Cufodontis, Enumeratio, Bull. Jard. bot. État Brux. 25(2): p. 306-307. (tax.)
1957: Kuls, Petermanns geogr. Mitt. 101: p. 248. (agric.)
1958: Kuls, Frankf. Geogr. Hft 32: p. 64, 66. (agric.)
1960: Simoons, Northwest Ethiopia: p. 71. (agric.)
1961: Huffnagel et al., Agriculture in Ethiopia: p. 202-203. (agric.)
1963: Cobley, An introduction to the botany of tropical crops: p. 164-165. (agric.)
1963: Kuls, Frankf. Geogr. Hft 39: p. 45. (agric.)
1963: Straube, Völker Süd-Aethiopiens 3: p. 99. (agric.)
1968: Purseglove, Tropical Crops, Dicotyl. 1: p. 319-321. (tax. + agric.)

Local names: ful (Arabic); baldenga, baldunga (Tigre); ater-bahari, ater-bar-ativari (Tigrinia); bakela, bagila (Amarinia, Gallinia).
Trade names: field bean (general name), tick bean or pigeon bean (small seeds), horse bean (medium-sized seeds), broad bean, Windsor bean (large seeds) (English); fève, fève de marais (French).

Geographic distribution

The origin of *Vicia faba* is in the Mediterranean region or south-western Asia, where it has been cultivated since ancient times. It is closely related to *Vicia pliniana* (Trabut) Mur. which grows wild in Algeria. Cultivars with 1 cm long seeds were widely grown in prehistoric times and later on by the ancient Egyptians, Hebrews, Greek and Romans. In western Asia they were early introductions and already in remote times they reached China and Japan. In the course of time they have become a common food in Europe. It is grown in temperate and subtropical regions, though several cultivars thrive in the parts of the tropics with a fairly cool season. The plant is an annual with field and garden cultivars. The field type is grown throughout the Middle East and down the Nile valley, in parts of India and Burma, and in many parts of western Asia. The garden type is cultivated on a small scale throughout Africa, in south-eastern Asia and parts of India; it has been introduced with success into the highland areas of Central America (Cobley, 1963; Purseglove, 1968).

In Ethiopia the cultivation is of considerable extent, but it is mainly found in Wollo and Begemdir. On most markets visited, seeds of *Vicia faba* were present.

Description

An erect, stiff, glabrous annual with a well-developed taproot with strong laterals; smaller roots with clusters of small, lobed nodules.

Stems stout, square (angles prominently ribbed), hollow with 1 or more basal branches.

Stipulae conspicuous, widely varying in shape and attached in different ways, irregularly dented, sometimes with a brown extra-floral nectary (an oval of glandular tissue).

Leaves alternate, pinnate, 2–6 leaflets; petiole grooved above, (0.5–)1.5(–3.5) cm long; rachis grooved above, (0–)3.5(–7.5) cm long, the terminal leaflet represented by a subulate, sometimes partly foliaceous mucro.

Leaflets sub-opposite or alternate, subsessile, obovate, (3–)6(–9.5) × (1–)2.5(–4) cm, entire, cuneate at base, mucronate at top (sometimes obtuse to retuse), grey-green.

Stipellae absent.

Inflorescence an axillary, subsessile, short raceme (1–6 flowers); rachis and short pedicels usually with scattered pubescent hairs; a minute bract present or not.

Calyx campanulate, glabrous or nearly so; tube ca 7 mm long; lobes 5, subequal, narrowly triangular, 5–8 mm long, the smaller upper lobes more or less paired (2–5 mm long).

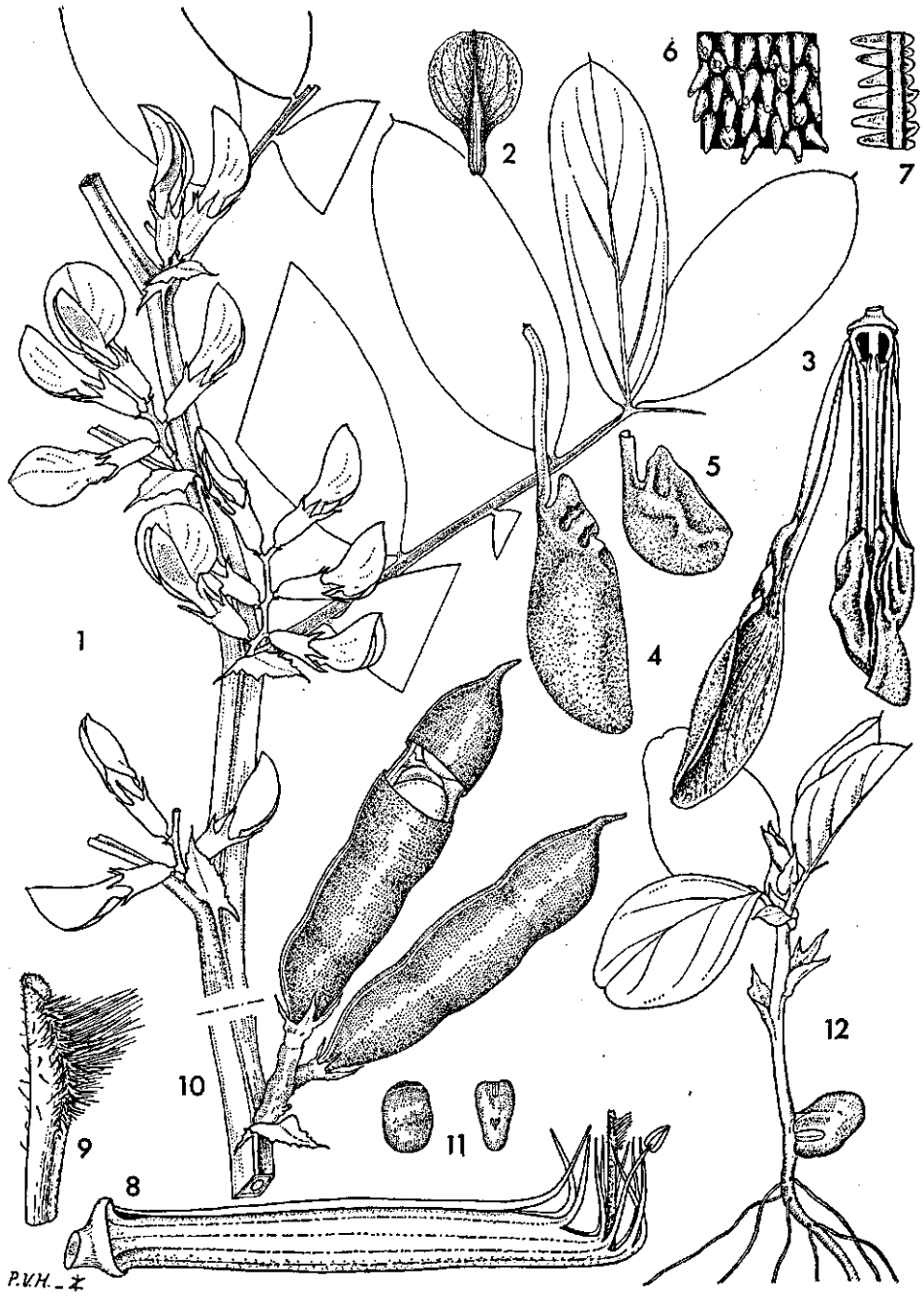


Fig. 25. *Vicia faba* L. cv. Abyssinica. – 1. branch with leaves and inflorescences (5/6×); 2. standard, abaxial view (5/6×); 3. wings and keel, dorsal view (2½×); 4. wing, abaxial view (2½×); 5. keel (2½×); 6. detail papillate part of wing, abaxial view (50×); 7. papillae on abaxial and adaxial side of wing (50×); 8. staminal sheath + pistil (5×); 9. style + stigma (15×); 10. pods (5/6×); 11. seeds (5/6×); 12. seedling (5/6×). – 1. WP 1777, WP 7627 (spirit mat.); 2–9. WP 7627 (spirit mat.); 10. WP 5599; 11. WP 7B; 12. WP 213.

Corolla with standard approaching the keel, finely spreading, broadly obovate, ca 2.5 × ca 1.5 cm, tapering into a broad claw, retuse or sometimes more or less obtuse and minutely mucronate at top, white with faint brown streaks. Wings oblong–obovate, ca 2.5 × ca 0.5 cm, with a long claw, auriculate, obtuse at top, adherent to the keel, white, marked by a dark brown blotch; apical part papillate. Keel ladle-shaped, ca 1.5 × ca 0.5 cm, entirely split dorsally, ventrally split near the base, clawed, bi-auriculate, white.

Androecium: Stamens diadelphous (9+1). Vexillary stamen free, ca 15 mm long, gradually winged towards the base. Staminal sheath ca 13 mm long when on either side the first filament is released; this is followed by one pair of stamens, followed again by a single stamen and then ending by the top stamen. Anthers ellipsoid to ovoid, ca 1 mm long, basifixed, dark brown.

Disk annular.

Gynoecium: Ovary sessile or nearly so, very slender, compressed, ca 14 mm long, puberulous, 2–5-ovulate. Style abruptly upturned, ca 3 mm long, glabrous, with an abaxial tuft of hairs near the stigma. Stigma terminal, glandular-papillate.

Pod narrowly oblong, cylindrical to flattened, bulging over the seeds, (3–)5–6(–8) × 1.0–1.5 cm, cuneate at base, beaked, sparsely puberulous, generally 2–5-seeded.

Seeds variable in shape and size, oblong to obovate, generally bolster-shaped or compressed, ca 1.0(–1.5) × less than 1 cm, dark brown, brown, reddish or green. Hilum prominent, narrowly oblong, on the short side. Funicle dilated at top, not persisting with the dry, detached seed. Cotyledons pale yellow.

Seedling with hypogeal germination. Epicotyl sometimes purplish. First 2 leaves simple, scale-like and fused with 2 lateral scale-like 'stipulae', generally tri-dentate at top, often the lateral teeth smaller. Generally the following 5 leaves 2-foliolate.

Note

Spirit in which seedlings, flowers and fruits had been preserved, showed a distinct dark colouring.

Taxonomic notes

(1) In LINN one sheet is present (906.34) carrying the specific epithet and the reference by number to Sp. Pl. ed. 1. As this specimen shows flowers (no fruits), it is impossible to establish immediately which taxon of *Vicia faba* has been described by Linnaeus, since differences between the various types are mainly based on size and shape of fruits and seeds. In Sp. Pl. ed. 1 Linnaeus mentioned '*Faba* minor sive equina' described by Bauhin (1623), and he considered it as a variant within *Vicia faba*. Bauhin separated '*Faba* major' and '*Faba* minor', differing in the size of the fruits. Linnaeus, by citing Bauhin's '*Faba*' (Pinax: p. 338 (1623)) as a synonym of *Vicia faba*, and distinguishing Bauhin's '*Faba* minor sive equina (l.c.) as the variety (β), clearly indicated that the type relates to the large-podded and large-seeded *Vicia faba* L. Under these circumstances it seems reasonable to adopt the specimen in LINN (906.34) as the lectotype of *Vicia faba* L.

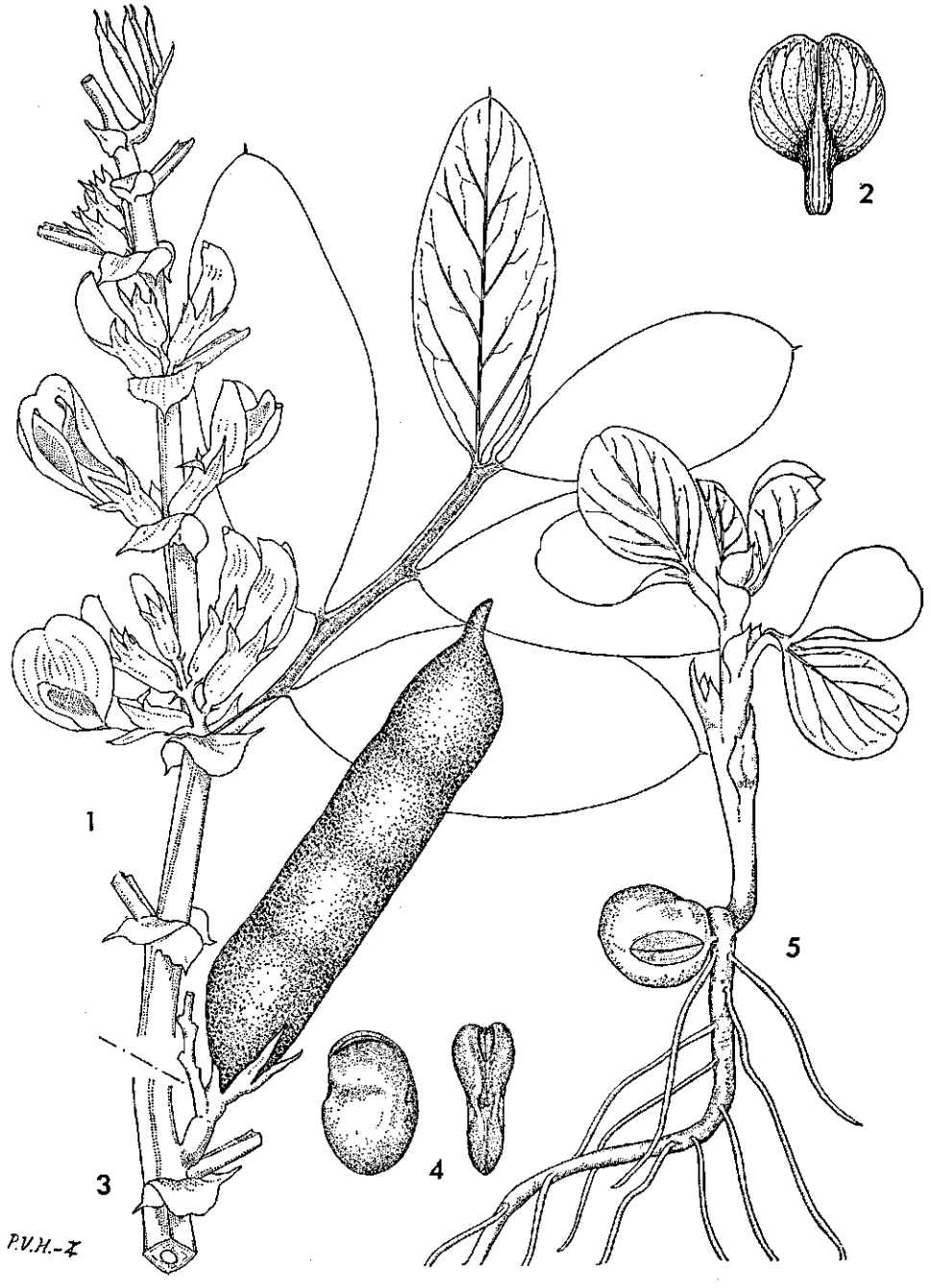


Fig. 26. *Vicia faba* L. cv. Giant Dawit. – 1. branch with leaf and inflorescences (5/6×); 2. standard, abaxial view (5/6×); 3. pod (5/6×); 4. seeds (5/6×); 5. seedling (5/6×). – 1. WP 7658, WP 7657 (spirit mat.); 2. WP 7657 (spirit mat.); 3. WP 7658 (spirit mat.); 4. WP 4058A; 5. WP 7656 (spirit mat.).

(2) Linnaeus (1753) united the genera *Faba* and *Vicia*, reducing the former to the rank of a species and singling out the variant β *minor*. In 1794, Moench returned to the pre-Linnaean concept of *Faba* as a genus. Other botanists agree with Linnaeus, but in recognizing the unique position of this taxon some of them single it out as a separate section.

(3) In agreement with his predecessors, Linnaeus distinguished only two groups of *Vicia faba*, regarding var. *minor* as a derivative from the typical *V. faba*. In 1807 Persoon singled out a third group with medium-sized seeds as β *equina*. The large-seeded flat and the small-seeded bolster-shaped group may be well-distinguished from one another on the morphological characteristics of the seeds and partly on those of the fruits. As to the vegetative parts of the plant, no sharp differences can be established. Neither are the two groups geographically strictly delimited. The group with medium-sized seeds occupies an intermediate position according to its morphological characteristics. The presence of additional forms still more tends to blur the demarcation line between the three groups.

According to Muratova (1931), two subspecies can be delimited within *Vicia faba:* subsp. *paucijuga*, referring to Indian forms with very small seeds, and subsp. *eu-faba*. The latter can be split up into three varieties: var. *major* (Harz) Beck with large seeds, var. *equina* Pers. with medium-sized seeds, and var. *minor* (Peterm. em. Harz) Beck with small seeds. The nature of the valves is a characteristic on which further subdivision into subvarieties is possible, as among the small, medium and large-seeded beans there are types with tender-valved, non-dehiscent and with coarse-valved, dehiscent pods. These subvarieties can be subdivided again into formae according to the shape and colour of the seeds, the colour of the hilum, flowers, leaves and stipules, the height and branching of the stem, and the length of the vegetation period. These formae may be arranged into groups differing in certain combinations of morphological features, as well as in their geographic distribution.

Muratova (1931) concludes that the Ethiopian material fits the var. *minor*, specifically the Mediterranean group of subvar. *tenuis*. Besides the typical form with light-coloured seeds (f. *abyssinica*), there occur, as a rare admixture, forms whose seeds are dark: brown-reddish (f. *rubescens*) or black (f. *rara*).

The Ethiopian beans are very uniform and the peculiar form of the beans is typical only for this country. Since the Ethiopian forms and some Afghan and Kashmir resemble each other, and as, in addition, the root of the local names ('baccla' or 'bogli' in Afghanistan) is identical, Muratova (1931) concludes, that Ethiopia can scarcely be an independent centre for this crop, and that this region stood in connection with south-western Asia.

It seems reasonable to maintain the two groups of different-sized seeds of *Vicia faba* as cv.-group Faba (the large-seeded) and cv.-group Minor (the small-seeded). Cv.-group Faba is typified by the specimen in LINN (see taxonomic note 1). In Sp. Pl. ed. 1 Linnaeus refers under β to '*Faba* minor sive equina' of Bauhin. In LINN no specimen of this taxon is present. In the Burser Herbarium a specimen is present with the following annotation: '*Faba* minor sive equina Bauh. In hortis'. However,

this specimen shows, contrary to Linnaeus's diagnosis of *Vicia faba*, tendrils (even branched ones). Juel (in: J. Burser's Hortus Siccus, Symb. Bot. Ups. 2: p. 126 (1938)) identifies this specimen as *V. narbonensis* L. Since Linnaeus refers in Sp. Pl. ed. 1: p. 737 under *V. narbonensis* to '*Faba* sylvestris, fructu rotundo atro. Bauh. pin. 338', which is according to Juel (l.c. p. 126) *V. narbonensis* L., it seems likely that either Burser made a mistake in identifying his specimen (nr. XIX-51) with Bauhin's '*Faba* minor', or that within *Vicia faba* β *minor* sometimes tendrils occur. Anyhow, Burser's specimen is not suitable for selection as the lectotype of cv.-group Minor.

In the literature var. *minor* is generally attributed to Beck. In: Ic. Reichb. 22: p. 175 (1903) Beck deals with *Vicia faba* and distinguishes α *minor* Beck, which probably is synonymous with var. *minor* Petermann (Flora Lipsiensis: p. 549 (1838)). In his Flora von Nieder-Österreich 2(1): p. 873 (1892) Beck only refers to Harz's Landwirtschaftliche Samenkunde 1: p. 661 (1885). Here Harz distinguished within *Faba vulgaris* Moench between var. *major*, var. *equina* Reichb. and var. *minor*, but he did not refer to Petermann. Petermann (l.c.) refers to *Vicia faba* β *minor* L., on which he comments: 'ex omei parte minor: flores e lacteo coerulescentes. Syn. *V. faba equina* Pers.' Since Beck is not the original author of var. *minor* it is not obvious to select his specimen of *Vicia faba* var. *minor* (PRC!) as the neotype. So I have selected Westphal 445, collected in Ethiopia, where this pulse is of ancient cultivation, as the neotype of *Vicia faba* cv.-group Minor. Duplicates were distributed to, for instance, Kew and Paris.

(4) The material collected by the author in Ethiopia fits the var. *minor*. It is mainly of the *abyssinica*-type as far as seed characteristics are concerned. However, several seed samples contain seeds outside the range for seed length mentioned by Muratova (0.65–1.25 cm) being as long as 1.5 cm. In three cases seed samples contained seeds of the *major*-type (WP 3369D, WP 4058A, S1 536), which apparently are from a recent introduction. These seeds and the plants raised from them differ from the bulk of the collected specimens in the following respects

flower: standard: ca 2.8 cm long, ca 2.8 cm wide (top emarginate).
pod: (5.5–)7.5–10.0 cm long, ca 2 cm wide.
seed: 2–2.5 cm long, 1.5–1.8 cm wide.

According to the seed types found in Ethiopia the following cultivars are proposed.

(A) Seeds large, green. I designate this taxon as cv. Giant Dawit (based on WP 4058A, WP 7656 and WP 7658).

(B) Seeds small

(a) brown, sometimes reddish-brown. I designate this taxon as cv. Abyssinica (based on WP 100, WP 312, WP 1820 and WP 5944).

(b) brown, glossy. I designate this taxon as cv. Glossy Makonnen (based on WP 2817A, WP 6644, WP 6645 and WP 6646).

(c) dark brown-black. I designate this taxon as cv. Rara (based on WP 5488B, WP 7665 and WP 7666).

The plants raised at Wageningen did not differ essentially from those grown in Ethiopia.

(5) The description is based on the following specimens.

Eritrea	Adi Caier market: SI 883.
Tigre	Adi Shoa market: SI 1030; Axum market: SI 936.
Begemdir	Gondar market: SI 869, SI 914.
Wollo	Kombolcha market: SI 967, SI 968; Bati market: SI 1046, SI 1047; Dese market: SI 1102; Haik market: SI 1135.
Gojam	Dejen market: SI 745, SI 767; Elias market: SI 790, SI 791.
Shoa	Debre Zeit market: WP 2983A, WP 2983B, WP 2983C; Addis Abeba market: WP 3025A, WP 3025B, WP 3025C, WP 3025D; Ghion market: WP 3248A; Shashamane market: WP 2597A, WP 2597B, WP 2597C; 30 km of Addis Abeba on Dese road, naturalized: W. J. de Wilde 10924; Robi market: SI 1152; Kuyera market: SI 1196.
Illubabor	Bedelle market: WP 5488A, WP 5488B, WP 5488C.
Kefa	Jima market: WP 3294A, WP 3294B, WP 3294C, WP 3295, SI 124, SI 128A; Serbo market: WP 3255A, 3255B, 3255C; Assendabo market: WP 3369A, WP 3369B, WP 3369C, WP 3369D; Agaro market: SI 85, SI 92, SI 109.
Sidamo	Dila market: WP 2817A, WP 2817B, WP 2717C; market at 12 km past Wondo on Dila road: WP 4058A, WP 4058B; Wondo market: WP 2811A, WP 2811B, WP 2811C, WP 2811D; Yirga Alem market: WP 2655A, WP 2655B, WP 2656C, WP 2656D; Awasa market: WP 2713A, WP 2713B, WP 2713C.
Bale	Goba market: SI 1226.
Arussi	Sire market: SI 160; in field, 82 km past Nazret on Asella road: WP 1592.
Hararge	Assebot market: SI 698; Asbe Teferi market: SI 470; Bedessa market: SI 664, SI 665; K'uni market: SI 534, SI 535, SI 536; Gelemso market: SI 621, SI 623; Moulou market: SI 440, SI 444; Ch'elenko market: SI 255; in field near Ch'elenko: WP 1018; Deder market: WP 384, WP 385; Wotter market: SI 213; Bedeno market: SI 321; Dire Dawa market: WP 123; Alemaya market: WP 7B; in field, 2 km on Kombolcha road: WP 445; garden on Kombolcha road: WP 386; Harar market: WP 44B, WP 50B, WP 100; garden Alemaya: WP 213, WP 256, WP 265, WP 312, WP 354, WP 741, WP 1054, WP 1063, WP 1071, WP 1079, WP 1777, WP 1820, WP 1832, WP 2178; Feddis market: SI 195.
Grown at Wageningen	WP 5598, WP 5599, WP 5753–WP 5758, WP 5780–WP 5785, WP 5859–WP 5861, WP 5941–WP 5946, WP 6061–WP 6066, WP 6207, WP 6208, WP 6479–WP 6484, WP 6504–WP 6507, WP 6542–WP 6545, WP 6547–WP 6550, WP 6618–WP 6628, WP 6644–WP 6652, WP 6823–WP 6831, WP 7054–WP 7063, WP 7627–WP 7663.

Ecology

Vicia faba is an annual from temperate regions, sometimes a biennial. It can be grown at high altitudes in the tropics, and as a winter crop in the subtropics, but it is not suited to low tropical regions, where it may flower well but usually produces no pods. It requires fertile soils with a good supply of lime and adequate and sustained water supply. It grows well on heavy clay soils (Purseglove, 1968).

Husbandry

Vicia faba matures in 3–7 months after sowing.

In Ethiopia it is found between ± 1800– ± 3000 m: it is essentially a field crop of the higher altitudes. Especially between (2000–) 2200–2400 (–2500) m it is frequently cultivated, together with pea, wheat and barley in the so-called cereal-pulse zone (Kuls, 1958). In the daga of Gojam it is found as high as 3200 m (Kuls, 1963), whereas in Begemdir and Wollo it is cultivated between ± 2300 and ± 3000 m in a rotation scheme immediately after cereals, or on poor, sometimes badly eroded soils where a fair crop still may be produced (Huffnagel et al., 1961). It is generally not grown in the dry season, but sometimes fields have been observed in Wollo with flowering plants in April. In the Yerer-Kereyu Highlands, on red soils, horse beans are sometimes sown in April at the same time as chickpeas (Kuls, 1957). The Amarro in Gamu Gofa cultivate it from September till January/February (Straube, 1963). Sometimes it is grown together with peas (Simoons, 1960). As a rule horse bean is found in rotation schemes together with wheat, barley and pea. Infrequently it is grown as garden crop.

Average yields of ca 920 kg/ha are recorded.

Uses

Vicia faba is grown as garden cultivars for the green shell beans and as a field crop for the dried beans which are used as food for man and animals. They are also grown for fodder and hay. In the Mediterranean region it is used as concentrate for livestock (Purseglove, 1968).

In Ethiopia seeds are consumed either roasted or to prepare 'wot", sometimes as porridge. They can also be eaten green.

Protein content

Leaves: ca 5.6% (Terra, 1966); young seeds: 2.3–9.3% (Terra, 1966); ripe seeds: ca 23% (Terra, 1966), 23.4% (Darby et al., 1959), ca 35% (Muratova, 1931).

(15) Vigna unguiculata (L.) Walp.

'*Vigna*': named after Dominico Vigna (15.., Florence; 1647, Pisa), since 1609 professor of botany at Pisa (since 1614 director of the botanic gardens at Pisa), author of a commentary on Theophrastos' 'Peri phyton historiae' and 'Peri phyton aition'.
'*unguiculata*': from Lat. unguis = nail or claw, unguiculus = small nail or small claw, so unguiculata = provided with a small claw.

(15A) Cv.-group Unguiculata

Figs 27, 28; Plates 66–68

Walpers, Rep. Bot. Syst. 1: p. 779 (1842), being *Vigna unguiculata* (L.) Walp.
Type: habitat in Barbados; '*Dolichos* volubilis, leguminibus capitatis subcylindraceis, apice recurvo concavo'. Neotype: Westphal 8682 (WAG, holo.; iso.: K, P).

Synonyms

Dolichos unguiculatus L., Sp. Pl. ed. 1: p. 725 (1753) (basionym).
Dolichos sinensis L., in: Herb. Amb.: p. 23 (1754), Cent. Pl. 2: p. 28 (1756), Amoen. Acad. 4: p. 132, 326 (1759).
Phaseolus sphaerospermus L., Sp. Pl. ed. 2: p. 1018 (1763).
Vigna sinensis (L.) Hassk., Cat. Pl. Hort. Bogor.: p. 279 (1844).
Vigna unguiculata (L.) Walp. var. *sinensis* (L.) Fiori (1910), see Cufodontis (1955).
Phaseolus unguiculatus (L.) Piper non sensu Piper, Torreya 12: p. 190 (1912).
Vigna sinensis var. *nigrocellata* Braun ex Harms, in: Engler, Die Pflanzenwelt Afrikas 3(1): p. 687 (1915).
Vigna sinensis ssp. *sinensis* (L.) Mansf., Vorläufiges Verzeichnis, Die Kulturpflanze, Beiheft 2: p. 209 (1959).
Vigna unguiculata ssp. *unguiculata* (L.) Verdc., Kew Bull. 24(3): p. 543 (1970).

(15B) Cv.-group Biflora — Fig. 28; Plates 69–72

'*Biflora*': from Lat. 'bi' and flos = flower, so two-flowered, or flowers paired.

Linnaeus, Sp. Pl. ed. 1: p. 727 (1753), being *Dolichos biflorus* L. (basyonym).
Type: habitat in India; '*Dolichos* erectis, caule perenni laevi, pedunculis biflorus, leguminibus erectis' (L, A. van Royen Herb., holo.!).

Synonyms

Phaseolus cylindricus L., in: Herb. Amb.: p. 23 (1754), Amoen. Acad. 4: p. 132 (1759).
Dolichos catjang Burm. fil., Fl. Ind.: p. 161 (1768); L., Mant. 2: p. 269 (1771).
?*Dolichos lubia* Forsk., Fl. Aegypt.-Arab.: p. 133 (1775).
Dolichos tranquebaricus Jacq., Hort. Vindob. 3: p. 39, t. 70 (1776).
Vigna catjang (Burm. fil.) Walp., Linnaea 13: p. 533 (1839).
Vigna sinensis (L.) Hassk. var. *catjang* (Burm. fil.) Chiov., Annali Bot. Roma 8: p. 438 (1908).
Vigna cylindrica (L.) Skeels, U.S.D.A. Bur. Plant Ind. Bull. 282: p. 32 (1913).
Vigna unguiculata ssp. *cylindrica* (L.) van Eseltine, in: Hedrick, Vegetables of New York 1(2): p. 11 (1931).
Vigna unguiculata ssp. *catjang* (Burm. fil.) Chiov., in: Raccolte Bot. Missionari Consolata nel Kenya: p. 35 (1935).

(15C) Cv.-group Sesquipedalis

'*Sesquipedalis*': from Lat. sesqui = one and a half, and Lat. pes = foot, so pedalis = a foot long; in botanical use inferring 'very long'.

Fruhwirth, Anbau Hülsenfr.: p. 254 (1898), being *Vigna sesquipedalis* (L.) Fruhw.
Type: habitat in America; '*Dolichos* volubilis, leguminibus subcylindricus laevibus longissimis, legumen ultra sesquipedale'. Neotype: Westphal 8677 (WAG, holo.; iso.: K, P).

Synonyms

Dolichos sesquipedalis L., Sp. Pl. ed. 2: p. 1019 (1763) (basionym).
Vigna sinensis (L.) Hassk. var. *sesquipedalis* (L.) Koern. ex Asch. & Schwfth, in: Ill. Fl. Egypt. in: Mém. Inst. Egypt. 2: p. 69 (1889).
Vigna sinensis ssp. *sesquipedalis* (L.) van Eseltine, in: Hedrick, Vegetables of New York 1(2): p. 11 (1931).

According to Cufodontis (1955) the yard-long bean is found in Eritrea and in the northern part of Ethiopia proper. However, it has not been collected by the author and consequently it is not taken into consideration here.

Literature (for 15A–C)

1747: Rumphius, Herbarium Amboinense 5: p. 375, 383; t. 134, 139 f. 1. (tax.)
1871: Baker, in: Oliver, Flora Tropical Africa 2: p. 204-205. (tax.)
1879: Baker, in: Hooker, Flora British India 2: p. 205-206. (tax.)
1912[a]: Piper, U.S.D.A. Bur. Plant Ind. Bull. 229: p. 1-30. (tax. + agric.)
1912[b]: Piper, Torreya 12: p. 189-190. (tax.)
1924: Gams, in: Hegi, Illustr. Flora 4(3): p. 1623-1624. (tax.)
1927: Heyne, Nuttige planten Ned. Indië 2: p. 842-845. (agric.)
1931: Ochse, Indische groenten: p. 434-438. (agric.)
1935: Merrill, Trans. Am. phil. Soc. New Series 24(2): p. 214-215. (tax.)
1937: Dalziel, Useful plants West Trop. Africa: p. 266-269. (tax. + agric.)
1944: Chevalier, Revue Bot. appl. Agric. trop. 24: p. 128-152. (tax. + agric.)
1951: Vavilov, Chronica bot. 13 (1-6): p. 21-38. (tax.)
1953: Whyte et al., Legumes in agriculture: p. 342-344. (agric.)
1954: Wilczek, Flore Congo Belge 6: p. 387-390. (tax.)
1955: Cufodontis, Enumeratio, Bull. Jard. bot. État Brux. 25(3): p. 336-337. (tax.)
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1961: Mateo Box, Leguminosas de grano: p. 301-304, 309-313. (tax. + agric.)
1962: Sellschop, Fld Crop Abstr. 15(4): p. 259-266. (tax. + agric.)
1963: Backer & Bakhuizen van den Brink, Flora of Java 1: p. 641-642. (tax.)
1963: Cobley, Introduction to the botany of tropical crops: p. 148-150. (tax.)
1963: Straube, Völker Süd-Aethiopiens 3: p. 28. (agric.)
1963: Wienk, Photoperiodic effects in V. unguiculata (L.) Walp., Meded. LandbHogesch. Wageningen 63(3): p. 3, 6-7, 73-75. (agric.)
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1965: Faris, Can. J. Genet. Cytol. 7(3): p. 433-450. (genetics)
1966: Burkill, Dict. ec. prod. Malay Peninsula 2: p. 2271-2274. (agric.)
1966: Stanton et al., Grain legumes in Africa: p. 117-127. (tax. + agric.)
1966: Terra, Tropical vegetables: p. 81-82. (agric.)
1968: Ojehomon, J1 W. Afr. Sci. Ass. 13(1): p. 106-109. (morph.)
1968: Purseglove, Trop. Crops, Dicotyl. 1: p. 321-328. (tax. + agric.)
1969: Sauer, Agric. origins and dispersals: p. 77. (agric.)
1970: Verdcourt, Kew Bull. 24(3): p. 542-545. (tax.)
1971: Krishnaswamy, in: Kachroo, ed., Pulse crops of India: p. 201-206, 220-227. (agric.)
1971: Verdcourt, in: Flora Trop. East Africa, Leg. 4, Papil. 2: p. 642-646. (tax.)

Local names

(a) Cv.-group Unguiculata: adonguari (Amarinia, Tigrinia); adagura, adagura-kwolla (Tigrinia); atera Argobba (Gallinia); gaisa (Chako); wuche, eka-wohe (Wollamo); lubia (Arabic); digir (Somali); fasolea-dima (Gallinia); arenguade (?); nori, nguno, nyoari (Anyowah). Possibly gaisa, wuche, eka-

wohe, fasolea-dima and arenguade refer also to the catjang cowpea.

(b) Cv.-group Biflora: atera kech'ene (Amarinia); adonguari (Amarinia, Tigrinia); adagura, adagura-kwolla, adugguari (Tigrinia); atera babile (Gallinia?, Aderinia?).

(c) Cv.-group Sesquipedalis: didjire (Arabic).

Trade names

(a) Cv.-group Unguiculata: (common) cowpea, black-eye bean, black-eye pea, southern pea, China pea (also for catjang?), kaffir pea (also for catjang?), marble pea (English); haricot dolique, dolique de Chine, haricot à oeil noir, pois de Brésil, niébé (French).

(b) Cv.-group Biflora: catjang, catjang cowpea (English).

(c) Cv.-group Sesquipedalis: yard-long bean, asparagus bean, snake bean (English); dolique asperge (French).

Geographic distribution

Cowpeas have been cultivated for thousands of years throughout the Old World tropics. It was known in India in Sanskritic times, and the early Greek and Romans grew it under the name 'phaseolus'. The question whether the Indian subcontinent or Africa is the centre of origin for the cultivated *Vigna unguiculata* is difficult to answer, because it has been grown for such a long time in both areas. This antiquity is also apparent from the entirely different names the crop has in the local languages of India and with virtually every tribe in Africa. Vavilov (1951) accepted Asiatic origin (Indian subcontinent) and considered China and Ethiopia as secondary centres. Sauer (1969) placed the centre of origin in Ethiopia, whereas Murdock (1959) suggested that cowpeas were domesticated at the headwaters of the Niger river (before 4500 B.C.). Sellschop (1962) concluded that the Orient certainly knew the cultivation of cowpeas long before Africa stirred. However, as the wild *Vigna unguiculata* is widespread in tropical Africa, it seems justified to conclude that it was first domesticated in west or central Africa. Whether it was indeed first domesticated around the headwaters of the Niger river, as suggested by Murdock (1959), will require a more detailed study of both cultivars and wild material from throughout West and Central Africa, together with further archæological investigations on the early civilizations in this region (Faris, 1965). Through the centuries it has been taken by traders from West Africa to the Indian subcontinent, where further selection by man has produced the Biflora and the Sesquipedalis types. From these two centres the crop has spread throughout the world (Faris, 1965). In the 16th century cowpea was brought by the Spaniards into the West Indies; around 1700 it was introduced in the U.S.A. It is now widely distributed in the tropics and subtropics (Purseglove, 1968).

After *Phaseolus vulgaris* the ocwpea is the most important pulse crop in tropical Africa. In Nigeria it ranks second after the groundnut. The seed cultivars are also grown in tropical Asia, but there they are less important than some of the indigenous pulses. Yard-long beans are an important vegetable crop in south-eastern Asia, particularly for Chinese market gardeners; they are also grown in the West Indies. In tropical America cowpeas are grown to a limited extent, more particularly in Venezuela. They are of some importance in the south-eastern states of the U.S.A.

(Purseglove, 1968). Cultivation on a large scale occurs in South Africa, Rhodesia, Australia and in the south of the U.S.A., where cowpeas are mainly grown as a fodder crop for domestic animals, and also as a cover and green manure crop (Wienk, 1963).

When botanists started to study tropical plants, they met with cowpeas, both from the West Indies and Asia. Linnaeus gave them different names. To increase the confusion, other botanists of his time and immediately after him, added more names: a consequence of the great number of taxa into which the crop had been shaped over its long period of service to man (Burkill, 1966).

In Ethiopia *Vigna unguiculata* is found mainly in the area around Harar and especially south-east of the town. Seed samples were collected there at several market places. According to Cufodontis (1955), the crop is also found in Eritrea; he also records cv.-group Sesquipedalis which has not been collected by the author.

Description

A prostrate, climbing or sometimes erect to suberect, nearly glabrous annual with a well-developed root system. Nodules sometimes present, ± globular.

Stems ± square, slightly ribbed, twisting, sometimes hollow, with scattered, mostly widely spaced minute spinelets; nodes (when fresh) usually violet.

Stipulae prominent, ovate, appendaged, acuminate, with prominent venation.

Leaves alternate, 3-foliolate. Petiole (3.5–)5.5–9.0(–25.0) cm long, sometimes purple at top, with pulvinus swollen and grooved above, glabrous (or with some spinelets) as is the rachis, (1.5–)2.5–4.5(–6.5) cm long, topped by a leaflet.

Leaflets: First leaflets opposite and (conspicuously) asymmetrical, top leaflet symmetrical, with petiolule short (ca 5 mm long) and slightly pubescent, ovate, (6.5–)7.0–13.5(–19.5) × (3.5–)4.0–9.5(–17.0) cm, entire, more or less truncate to cuneate at base, very broad, often incurved at either side, acuminate, acute or rounded, mucronate or rarely emarginate at top, top leaflet sometimes shallowly lobed at base or rhomboid, palmately 3-nerved, green, glabrescent to glabrous, light green below with venation more prominent.

Stipellae small, variable in shape, generally ovate–subulate, at the base of the petiolule; 1 per lateral leaflet, 2 per top leaflet.

Inflorescence an axillary raceme with several flowers clustered near the top. Peduncle (4.0–)10.0–17.0(–32.0) cm long, slightly twisted and ribbed, flattening towards the base, glabrescent at top, often purplish at base. Rachis contracted, glabrescent, tuberculate; fertile flowers paired, laterally inserted to a tubercle (cushion) carrying abortive flowers which leave gland-like tissue after being shed[22]; bracts 1

22. The description of the inflorescence of *Vigna unguiculata* in literature may be summarized as follows: the peduncle, arising in the axil of a leaf, is long. At the top several flower-pairs are arranged alternately, in a racemose manner. Between each pair of flowers there is a raised cushion with several extra-floral nectaries or glands which exude a sweet liquid.

Each flower-pair is the remnant of the basic unit of flower formation – the cushion unit or simple

per flower, early deciduous, ca 4 mm long, spathulate, fleshy at base, with 3 prominent veins, with slightly ciliolate edge, as is the bract subtending each group of flowers, ca 2 mm long; pedicels very short, with 2 bracteoles attached at the base of the calyx. Bracteoles deciduous, obovate, ca 3–5 mm long, frequently spathulate, fleshy at base with prominent venation, with slightly ciliolate edge, sometimes denticulate near base.

Calyx campanulate, longitudinally ribbed, transversely plicate-tuberculate; tube ca 5 mm long, fleshy at base; lobes 5, subequal, upper pair partly connate, narrowly triangular, ca 5–7 mm long, acuminate at top (in bud with curved beak), with ciliolate edges, sometimes purplish.

Corolla: Standard erect and spreading or reflexed, hood-shaped when older and enclosing wings and keel[23], transversely elliptic to very broadly obovate, (19–)23(–25) × (25–)30(–35) mm, with claw concave, bi-auriculate, with auricles inflexed, fleshy and prominent, sometimes left and right a second (prominent) auricle present, which is inflexed and/or folded, with two prominent longitudinal ridges above the auricles, enclosing the upper part of the wings, emarginate at top, glabrous, yellow-green outside, violet-blue inside with two yellow spots. Wings obovate, (20–)22(–25) × (11–)12 (–14) mm, clawed, auriculate (sometimes bi-auriculate), finely transversely striate near the auricle, slightly 'pocketed', rounded at top, glabrous, violet, adherent by the 'pockets' to the keel. Keel boat-shaped, (19–)21(–23) × ca 12 mm, clawed, dorsally split near the base and at the top, ventrally split near the base, left and right weakly 'pocketed', glabrous, white.

Androecium: Stamens diadelphous (9+1). Vexillary stamen free, (20–)22(–26) mm long, slightly winged, geniculate at base, upper part upturned. Staminal sheath auricled at base, with fleshy auricles, (14–)16(–20) mm long when on either side the first filament is released; this is generally followed by 3 single stamens after which the top stamen is finally released; free part of filaments (6–)7–8(–10) mm long, upturned, winged, with wings widening near the top, alternating slightly longer and shorter, when longer anthers basifixed, when shorter anthers dorsifixed. Anthers ellipsoid, ca 1 mm long, yellow.

Disk collar-shaped, ca 1 mm long, oblique, ribbed, repandous.

Gynoecium: Ovary sessile, laterally compressed, (11–)13(–16) mm long, apical part sterile, slightly pubescent, (12–)14(–21)-ovulate. Style upturned, (12–)15(–16) mm long, at the base laterally compressed, shortly beaked beyond the stigma, with the upturned part adaxially barbate, with patent fine hairs below the stigma. Stigma globular,

raceme – in *V. unguiculata*. The persisting flower-pair is lateral to the cushion (= tubercle), whereas the remaining flowers are borne on the cushion. Subsequently, the flowers on the cushion abort and drop leaving gland-like scars on the cushion, whereas the lateral flower-pair develops to anthesis. It is doubtful whether there is any justification for calling the glands 'nectaries' and their exudate 'nectar'. It is probable that the sugary exudate is a product of autolysis of the flower stalk and underlying tissues (Ojehomon, 1968).

23. Early in the morning, just after the opening of the flower the standard is erect and spreading (or reflexed), but after a few hours it turns forward and encloses the wings and keel.

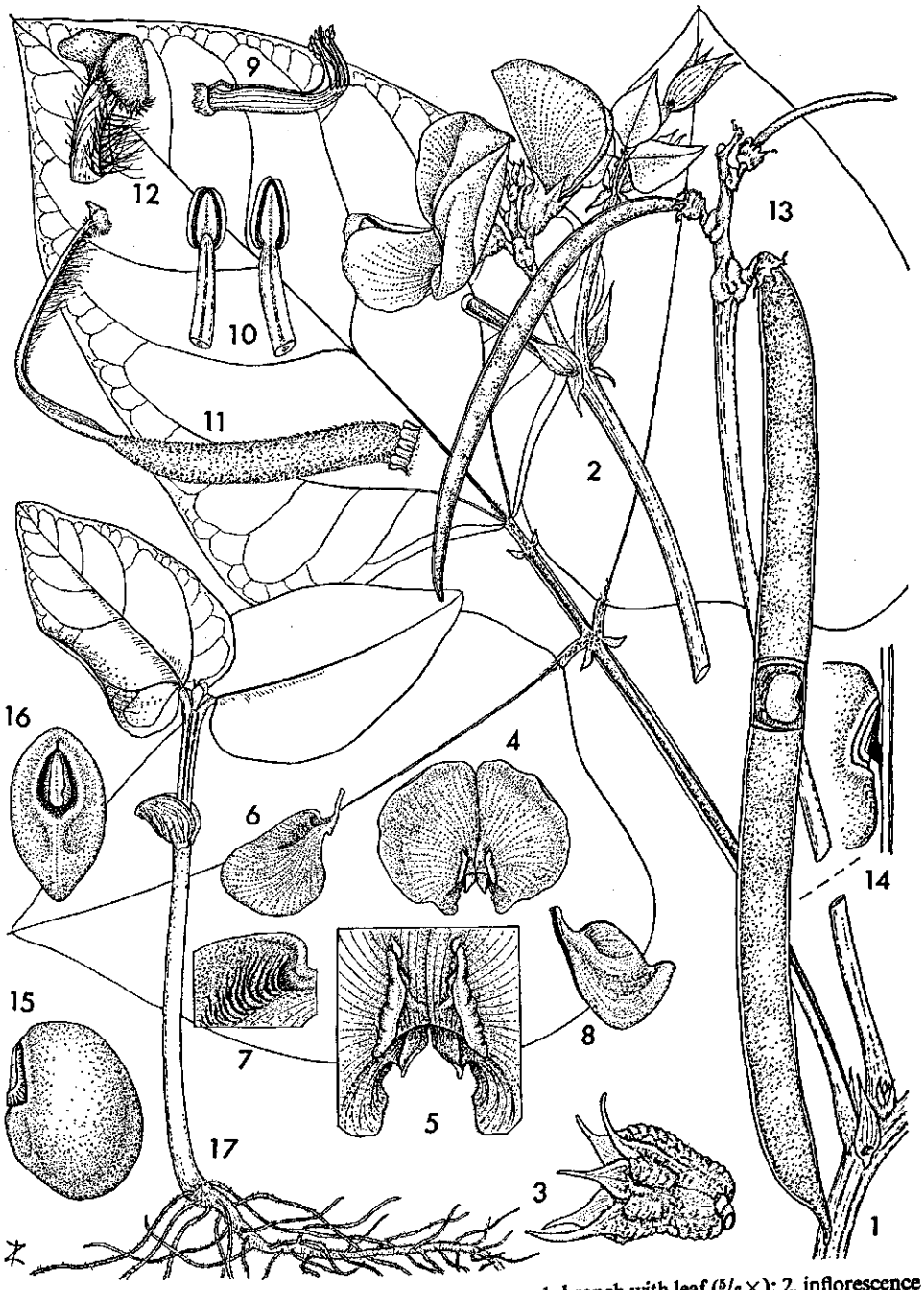

Fig. 27. *Vigna unguiculata* (L.) Walp. cv. Ras Makonnen. – 1. branch with leaf (5/6×); 2. inflorescence (5/6×); 3. calyx (2½×); 4. standard, adaxial view (5/6×); 5. standard, adaxial detail of basal part (2½×); 6. wing, abaxial view (5/6×); 7. wing, detail with 'pocket' (2½×); 8. keel (5/6×); 9. staminal sheath (5/6×); 10. anthers (7½×); 11. pistil (2½×); 12. stigma (7½×); 13. inflorescence with pods (2½×); 16. seed, with hilum (2½×); 17. seedling (5/6×). – 1. WP 8682; 2. WP 7948 (including spirit mat.); 3–12. WP 7948 (spirit mat.); 13. WP 8682; 14. WP 7949; 15–16. SI 343; 17. WP 8691 (spirit mat.).

surrounded at base by fine shorter hairs, directed adaxially, glandular, orange-yellow.

Pod pendent, or erect, or spreading, linear, slightly curved, slightly laterally compressed or sub-cylindrical, slightly bulging over the seeds, 8.5–20.0(–23.0) cm × 5–10(–12) mm, with ± curved beak, and dorsally flattened and grooved or concave, glabrous or nearly so, minutely verruculose, light brown, sometimes purplish-tinged, (6–)10–17(–21)-seeded; seeds separated by varying amounts of intermediate (sept-like) tissue.

Seeds variable in size and shape, ± square to oblong, sometimes ± globular, frequently laterally compressed, (5–)6–8(–9.5) × 4–6(–8) mm, light–dark brown, red, black, light brown with brown mosaic (or brown with light brown mosaic), light brown with greyish or/and violet mosaic, or white with a brown ring around hilum. Hilum oblong, excentric, 1/3–1/2 of the length of the seed, green, covered with a white tissue, with a dark coloured rim-like aril. Cotyledons white-pale yellow.

Seedling with epigeal germination. Hypo- and epicotyl glabrous; cotyledons oblong or sickle-shaped, lower surface grooved; petiole glabrescent. First two leaves opposite, simple, ovate, sometimes triangular, (2.0–)3.0(–6.0) × (1.5–)2.5(–4.0) cm, glabrous, truncate at base, obtuse at top; edges sometimes dented, frequently sparsely ciliolate and/or verruculose. Stipulae of the first two leaves connate. Stipellae absent.

Note

A selection of 25 cowpea seed samples has been raised in summer time in the greenhouse at Wageningen under the there prevailing long-day circumstances. Only 6 cultivars came into flower and fruited. Two of them, WP 3231D from Gidole and WP 3381 from a Shankalla market in Wellega, flowered after ca 2 months and produced mature fruits after ca 2.5 months. The other four, WP 86B, WP 2556B, WP 3032N and WP 3188F (all from Harar region), flowered after ca 3–4 months and produced mature fruits after ca 4–5 months. Later on a selection of seed samples was raised under short-day circumstances (11 hours) in the greenhouse again. All cultivars flowered and fruited.

Taxonomic notes

(1) Linnaeus described several taxa which are now considered to belong to *Vigna unguiculata*. The taxa described by him are listed below.

(a) *Dolichos unguiculatus*, Sp. Pl. ed. 1: p. 725 (1753): '*Dolichos* volubilis, leguminibus capitatis subcylindraceis: apice recurvo concavo.' Hort. ups. 214. Habitat in Barbados. This is the common cowpea.

(b) *Dolichos biflorus*, Sp. Pl. ed. 1: p. 727 (1753): '*Dolichos* erectus, caule perenni laevi, pedunculis biflorus, leguminibus erectis.' Roy. lugdb. p. 368. Habitat in India. This is the catjang cowpea.

(c) *Dolichos sinensis*, Amoen. Acad. 4: p. 326 (1759): '*Dolichos* caule volubili, pedunculis multifloris erectis, leguminibus pendulis cylindricis torulosis'.
Dolichos sinensis Rumph. amb. 5: p. 375, t. 134.
'Legumina communiter in singulo pedunculo duo vel tria. Semina esculenta a nautis emuntur in China pro alimento & viatico'.
(earlier published in Stickmann's Herb. Amb.: p. 23 (1754); Cent. Pl. 2: p. 28 (1756),

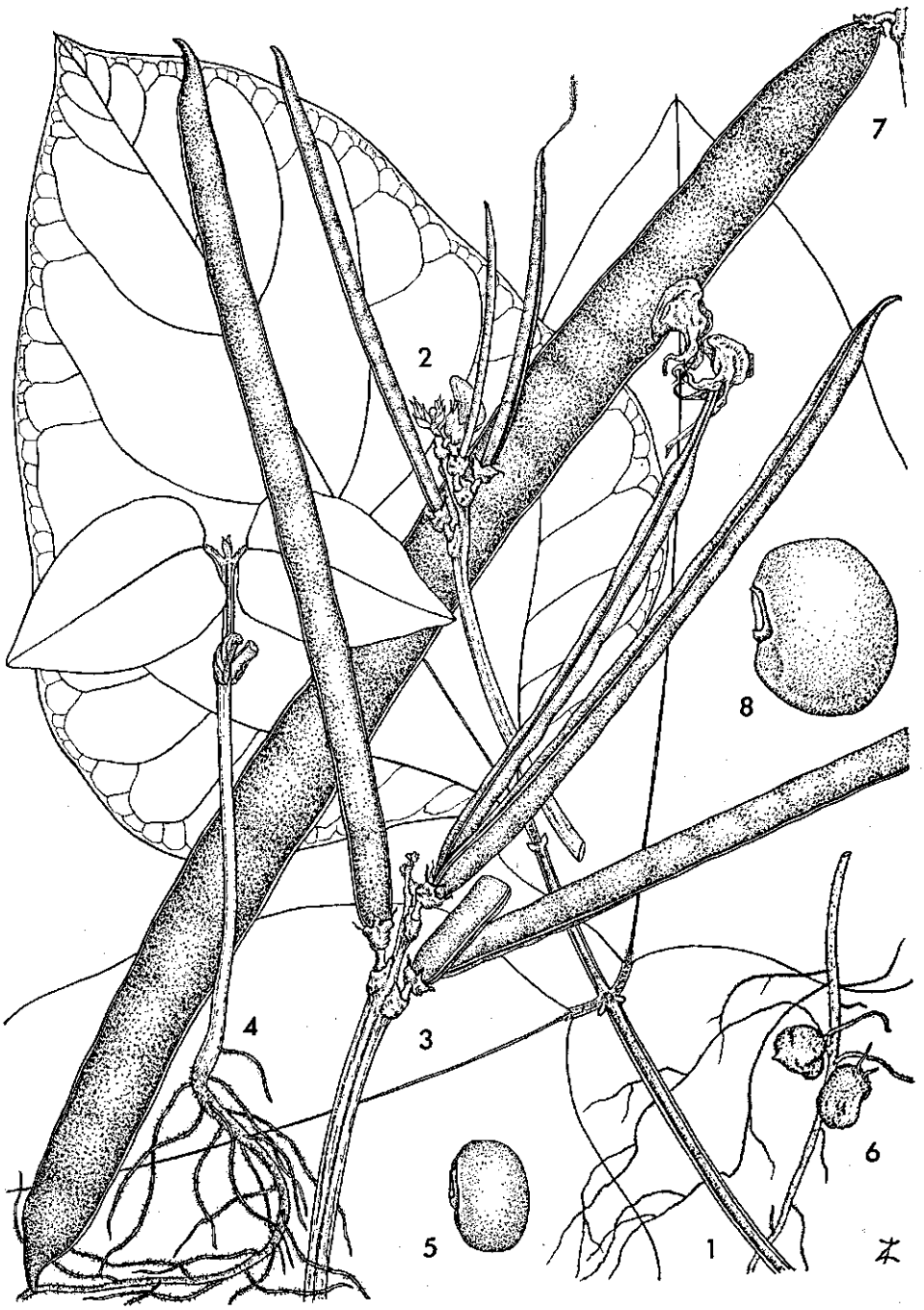

Fig. 28. *Vigna unguiculata* (L.) Walp. cv. Gidole. – 1. leaf (5/6×); 2. inflorescence with young pods (5/6×); 3. mature pods (5/6×); 4. seedling (5/6×); 5. seed, lateral view (2½×); 6. root nodules (5/6×). Cv. Giant Argobba. – 7. pod (5/6×); 8. seed, lateral view (2½×). – 1–3. WP 8679; 4. WP 8690 (spirit mat.); 5. Sl 619; 6. WP 8646 (spirit mat.); 7. WP 8686; 8. Sl 172A.

and Amoen. Acad. 4: p. 132 (1759)).
This is again the common cowpea.
(d) *Phaseolus sphaerospermus*, Sp. Pl. ed. 2: p. 1018 (1763): '*Phaseolus*? caule erecto, seminibus globosis hilo tincto†.'
Phaseolus erectus, siliquis gracilibus teretibus polyspermis, seminibus subrotundis hilo nigro. Brown. jam. 292.
Phaseolus erectus minor, semine sphaerico albido hilo nigro. Sloan. jam. 72. hist. 1. p. 185. t. 117. f. 1, 2, 3.
Phaseolus indicus, fructu stricto albo minore nigra macula. Pluk. alm. 290.
Habitat in Indiis.
This is the common cowpea, listed as cv. Black-eyed Lady (Piper, 1912).
(e) *Dolichos sesquipedalis*, Sp. Pl. ed. 2: p. 1019 (1763): '*Dolichos* volubilis, leguminibus subcylindricis laevibus longissimis'. Habitat in America.
'Facies Phaseoli: Flores vexillo supra pallido, intus rufescente. Legumen ultra sesquipedale, teretiusculum apice unguiculo obtuso gibbo.'
This is the yard-long bean.
(f) *Dolichos catiang*, Mant. 2: p. 269 (1771): '*Dolichos* caule erecto, leguminibus geminis linearibus erectiusculis.' Burm. ind. 161.
Phaseolus minor Rumph. amb. 5, p. 383, t. 139. f. 1.
Peru. Rheed. mal. 8, p. 75, t. 41.
Habitat in India orientali.
This is the catjang cowpea.
(g) Rumphius's *Phaseolus minor* has been given the name *Phaseolus cylindricus* L. (1759; authorship often attributed to Stickmann), which is thus an older name than *D. catjang* (1768).

In 1839 Walpers moved *D. catjang* Burm. fil. and in 1842 *D. unguiculatus* L. into *Vigna* (Linnaea 13: p. 533 and Rep. Bot. Syst. 1: p. 779, resp.). *D. sinensis* L. has been moved by Hasskarl into *Vigna* in 1844 (Cat. Pl. Hort. Bogor.: p. 279), and in 1898 Fruwirth did the same with *D. sesquipedalis* L. (Anbau Hülsenfr.: p. 254). Finally, in 1913, Skeels considered that *P. cylindricus* L. belongs to *Vigna* too (U.S.D.A. Bur. Plant Ind. Bull. 282: p. 32), whereas Brenan considered *D. biflorus* L. a synonym of *Vigna unguiculata* (Mem. N.Y. bot. Gdn 8(5): p. 415-416 (1954)).

(2) The nomenclature and typification of cv.-group Unguiculata.

In Sp. Pl. ed. 1 Linnaeus described *D. unguiculatus* and cited as the only reference Hort. ups. 214. In Hortus Upsaliensis (1748) a plant is described which has been grown in Uppsala Botanic Garden from seeds received by Linnaeus from Barbados. It appears that no specimen has been kept (there is no specimen in LINN nor in the herbarium of Uppsala). The oldest generally accepted binomial for the cowpea is *Dolichos unguiculatus*, but since no type is extant and the description seems too inadequate to be certain as to its identity, it has been rejected on several occasions (Piper, 1912; Merrill, 1935; Chevalier, 1944; Mansfeld, 1959). In its place the combination *Dolichos sinensis* L. has been chosen, being the oldest then known combination next to *D. unguiculatus*, since their is no doubt on its identity being typified by the

plate of Rumphius's *Dolichos sinensis* (Herb. Amb. 5: t. 134 (1747)). This choice, however, is unsatisfactory, since it solves the problem of the typification of *D. unguiculatus* by simply ignoring it. Sellschop (1962) suggests that it would be preferable to take as the type Linnaeus's original description of *D. unguiculatus*, to admit that a type specimen has not so far come to light, and that the correct name for the cultivated cowpea is *Vigna unguiculata* (L.) Walp. Verdcourt (1971) adopts this suggestion and typifies *V. unguiculata* with 'specimen grown in Uppsala Botanic Garden from seeds received by Linnaeus from Barbados (lecto.)', without reference to a specimen typifying his taxon. According to the Code (Article 9, Note 1) it may be possible to accept a description as the type of a taxon, if the name of that taxon is 'without a type specimen'. This is exactly what Sellschop has suggested. Verdcourt refers to a plant grown by Linnaeus in the Botanic Gardens of Uppsala, but in fact he does not refer to the description of *D. unguiculatus* L. This solution is unsatisfactory and it seems preferable to retypify *V. unguiculata* by designating a neotype which fits the original description.

In Sp. Pl. ed. 2: p. 1019 (1763) Linnaeus cited as the second reference *Cacara nigra* of Rumphius (Herb. Amb. 5: p. 381, t. 138 (1747)), following Stickmann (Herb. Amb.: p. 23 (1754), see also Amoen. Acad. 4: p. 132 (1759)). However, this is not the cowpea, but *Mucuna pruriens* (L.) DC. f. *utilis* (Wall. ex Wight) Backer (De Wit, 1959). De Candolle (Prodr. 2: p. 400 (1825)) refers under *D. unguiculatus* to Jacquin (Hort. Vindob. 1: t. 23 (1772)), whereas Willdenow (Sp. Pl. 3(1): p. 1038 (1800)) refers to Linnaeus's Hort. Ups., Jacquin's Hort. Vindob., Rumphius's Herb. Amb. and Houttuyn. Jacquin (l.c. p. 8) extensively described Linnaeus's *D. unguiculatus* without mentioning the origin of his plant, and depicted it as well (l.c. t. 23). It shows a specimen with erect fruits. However, Jacquin does not give in his description of *D. unguiculatus* L. any indication of the erect or pendent position of the pods, nor does Linnaeus. Possibly Linnaeus considered the pendent position of the pod as normal and thought special reference to it as superfluous. On the other hand it is thinkable that Linnaeus considered the position of the pod as being an unimportant characteristic as compared with others, or subject to considerable variation and thus not suitable as a diagnostic characteristic. However, in describing *Dolichos biflorus*, published at the same time in Sp. Pl. ed. 1, and which is the catjang cowpea, Linnaeus specifically mentions the erect position of the pods. Although Linnaeus's description of *D. unguiculatus* does not exclude a plant with erect pods (as e.g. is seen on Jacquin's plate), it is very unlikely. It is not apparent what led Jacquin into error, but the plant he figured is, according to Piper (1912b), the catjang cowpea. Consequently Jacquin's plate (l.c. t. 23) is not suitable to be designated as the neotype of *V. unguiculata*. Coincidentally, Chevalier (1944) is of the opinion that *D. unguiculatus* L. is in fact *D. catjang* Burm. fil.; also Purseglove (1968) considers *V. unguiculata* sensu stricto to be the catjang cowpea ('catjung'!).

At any rate, it is necessary that a neotype should be designated to remove all uncertainty on the identity of *V. unguiculata* in accordance with all available data. A Barbados specimen might seem desirable, but *V. unguiculata* certainly is not native

there and any specimen from that island, in Linnaeus's time or thereafter, is bound to represent an introduced taxon, which may have come from anywhere in the tropics.

The origin of *V. unguiculata* is unknown; West or Central Africa are the most likely (cf. Faris, 1965). However, Linnaeus may have had any taxon within *V. unguiculata* at his disposal. So I have selected as neotype Westphal 8682, grown from seeds collected in Ethiopia, where this pulse has been in cultivation since times immemorial. Specimens were grown at Wageningen, and duplicates have been distributed to Kew and Paris.

(3) The nomenclature and typification of cv.-group Biflora.

In Sp. Pl. ed. 1 Linnaeus described *Dolichos biflorus* and cited as the only reference Roy. lugdb. 368. In Florae Leydensis Prodromus (1740) A. van Royen described a *Dolichos* with erect habit and erect pods. In his herbarium (Leiden) a specimen is present, bearing a label saying '*Dolichos biflorus* L. Sp. 2. 1023' in D. van Royen's hand, and an old label saying '229/36 *Phaseolus* indicus siliqua prorsum vigente, flore extus albo intus pallide violacea, semine candido'. This description is neither mentioned in A. van Royen's Florae Leydensis Prodr., nor found elsewhere. This specimen of Van Royen is *Vigna unguiculata* (L.) Walp. (teste Brenan, 1954). In the descriptive sentence used by Van Royen and Linnaeus for *D. biflorus*, taking into account the 'Erecti' in which Linnaeus placed the species, the erect smooth stems and the pedunculate flowers do not apply to any plant which later authors have put under *Dolichos biflorus* in its widest sense. On the other hand, the descriptive sentence referred to fits in well with *Vigna unguiculata* and the specimen of A. van Royen. There is evidence that at the time of D. van Royen (2nd part 18th century) at Leiden the name *Dolichos biflorus* was applied to *Vigna unguiculata*, and that the plant which subsequently became known as *D. biflorus* was given a different name (namely *Dolichos kolii*, as is found on the label of a specimen in Meerburgh's herbarium at Leiden), as stated by Brenan, who continued: 'so far there is no evidence that *D. biflorus* (i.e. *V. unguiculata*) and *D. uniflorus* were anything but clearly distinguished from each other. The trouble seems to date from Murray's thirteenth edition of the Systema naturae (1774), for on p. 548 he adds as a synonym of *Dolichos biflorus* '*Phaseolus* vulgaris lablab effigie, flore parvo ochroleuco, siliquis falcatis gemellis. Pluk. alm. 291. t. 213. f. 4." The plant described and figured by Plukenet is clearly *D. uniflorus* and not *V. unguiculata*. Since then *D. biflorus* has been generally applied to *D. uniflorus* or related species of *Dolichos*, and not at all to *Vigna unguiculata* (Brenan, 1954).

Dolichos biflorus is, in fact, the catjang cowpea and thus an older name for *Dolichos catjang* Burm. fil. (1768) and *Phaseolus cylindricus* L. (1759). I am following Brenan in accepting the specimen in A. van Royen's herbarium, labelled *Dolichos biflorus* by D. van Royen, as the holotype of this taxon (being *Vigna unguiculata* (L.) Walp. cv.-group Biflora, the catjang cowpea), although considering the specimen as a lectotype may be more appropriate.

(4) The typification of cv.-group Sesquipedalis.

In Sp. Pl. ed. 2 Linnaeus described *D. sesquipedalis* without referring to other literature sources. No specimen is present in LINN. So I have selected Westphal 8677,

grown from seeds collected in Suriname, as the neotype of *Vigna unguiculata* cv.-group Sesquipedalis, being the yard-long bean.

(5) West African and Indian populations showed to differ markedly in size and shape of the seeds, probably because man has selected *Vigna unguiculata* for different purposes in these two areas. In West Africa it are chiefly the large-seeded cultivars cultivated for their dry seed, resulting in the common cowpea. On the Indian subcontinent the catjang cowpea mainly serves as a forage crop, and selection did not influence the size of the originally small seeds. The long, narrow-seeded type of the yard-long bean, which is associated with a very long, flabby pod, has been selected as a snap bean (Faris, 1965), possibly in south-east Asia.

The main differences between the cultivated taxa are the length, erectness and flabbiness of the pods, the size and the shape of the seeds, and their spacing in the pods. These properties vary widely, and their circumscription is subject to considerable personal bias, so that they are hardly suitable to segregate species, the more so as, due to hybridization, many intermediate taxa appear (Sellschop, 1962). Repeatedly these infraspecific taxa have been considered as subspecies differing in many genes affecting both qualitative and quantitative characteristics. Nevertheless, they exhibit almost similar karyotypes and are easily intercrossable, with fully fertile hybrids showing Mendelian inheritance. It certainly is unwarranted to adopt these taxa as distinct species (Sen & Bhowal, 1960).

The taxonomy of the section *Catiang* (DC.) Verdcourt of the genus *Vigna* Savi has been approached in various ways, and as it includes a number of well-known cultivated plants a voluminous literature has grown up. The main question is: are the wild African plants conspecific with the crop plants, and is more than one species involved (Verdcourt, 1970).

(6) The wide infraspecific variation of *Vigna unguiculata* (L.) Walp. leaves ample opportunity for different classifications. Some authors distinguish the cultivated taxa as different species.

Voigt (in Hortus Sub. Calcutt.: p. 232 (1845)) distinguished within *V. sinensis* the following varieties: (a) var. *eccremocarpus:* the cowpea; (b) var. *orthocarpus:* the catjang cowpea; (c) var. *sesquipedalis:* the yard-long bean.

Piper (1912a), who considered the cultivated cowpea to be *V. sinensis*, gives the following characteristics of the three distinguishable taxa.

(a) The cowpea: seeds 6–9 mm long, varying from subreniform to subglobose; pods 20–30 cm long, early becoming pendent, neither flabby nor inflated when green.

(b) The catjang cowpea: seeds 5–6 mm long, nearly as thick as broad, oblong or cylindrical, slightly reniform; pods 7.5–12.5 cm long, erect or ascending when green, remaining so or becoming spreading or deflexed when dry, neither flabby nor inflated when green.

(c) The yard-long bean: seeds 8–12 mm long, reniform; pods 30–90 cm long, pendent, fleshy, brittle, inflated, flabby, shrinking between the seeds before drying.

Stanton et al. (1966), who considered the cultivated cowpea to be *V. sinensis* and the wild cowpea *V. unguiculata*, give the following taxonomic and agronomic

characteristics.

(a) Ssp. *sinensis:* seeds usually large, variable in colour, with smooth or wrinkled seed coat; dormancy usually absent; flowers blue-purple to white; leaves hoe-shaped (ovate–heart-shaped); pods 10–20 cm long, straight, flattened with curved apex (rams' horn), pendent; plant habit trailing or bushy; photoperiodic response day-neutral or short day; medium to late maturing (70–140 days).

(b) Ssp. *catjang:* seeds variable in shape, variable in colour, with smooth or wrinkled seed coat; dormancy usually absent; flowers blue-purple to white; leaves hoe-shaped; pods 6–10 cm long, cylindrical, straight or slightly curved, erect; plant habit erect; photoperiodic response day-neutral; early maturing (55–90 days).

(c) Ssp. *sesquipedalis:* seeds large, usually black (African cvs), with wrinkled seed coat; dormancy usually absent; flowers white; leaves hoe-shaped; pods 50–100 cm long, straight, pendent; plant habit climbing; photoperiodic response day-neutral; medium maturing (African cvs).

(d) *V. unguiculata:* seeds small, yellow-grey to dull grey-green with black motling (or all black), with smooth seed coat; dormancy strongly developed; flowers blue; leaves spear-shaped; pods 3–8 cm long, cylindrical, straight or slightly curved, erect; plant habit trailing; photoperiodic response commonly short-day; range of maturity not fully investigated.

Purseglove (1968) gave the following differences between the various taxa of *V. unguiculata.*

(a) The common cowpea: a spreading, sub-erect or erect annual, 15–80 cm high; pods 10–30 cm long, pendent (even when young), hard and firm, not inflated when young; seeds usually 6–10 mm long *(Vigna sinensis).*

(b) The catjang cowpea: a spreading, sub-erect or erect annual, 15–80 cm high; pods 7.5–12 cm long, erect or ascending, hard and firm, not inflated when young; seeds usually 3–6 mm long *(Vigna unguiculata).*

(c) The yard-long bean: a climbing annual, 2–4 m high; pods 30–100 cm long, pendent, more or less inflated and flabby when young; seeds usually 8–12 mm long *(Vigna sesquipedalis).*

If it is desired to separate the cultivated forms from the wild *V. unguiculata,* the former should then, according to Purseglove, bear the name *V. sinensis.*

Verdcourt (1970, 1971) distinguished the following subspecies of *V. unguiculata.*

(a) Ssp. *unguiculata:* twining or sometimes erect; calyx-lobes mostly shorter than the tube, 2.5–5 mm long; pods 20–30 cm long, over 5 mm wide, generally indehiscent (the cultivated cowpea).

(b) Ssp. *cylindrica:* frequently sub-erect, but sometimes twining; calyx-lobes mostly shorter than the tube, 2.5–5 mm long; pods 7.5–13 cm long, over 5 mm wide, generally indehiscent (the catjang cowpea).

(c) Ssp. *sesquipedalis:* mostly twining; calyx-lobes mostly shorter than the tube, 2.5–5 mm long; pods 30–90 cm long, over 5 mm wide, generally indehiscent (the yard-long bean).

(d) Ssp. *dekindtiana* (Harms) Verdc.: prostrate or climbing; calyx-lobes mostly

shorter than the tube, 2.5–5 mm long; pods 5.5–10 cm long, 3–5 mm wide, mostly dark and scabrous when mature, dehiscent (the common wild cowpea, occurring throughout tropical Africa and sometimes cultivated in other parts of the tropics). (e) Ssp. *mensensis* (Schwfth) Verdc.: similar to ssp. *dekindtiana* buth with the calyx-lobes much longer than the tube, although varying from 5–14 mm (a wild taxon)[24].

I propose to designate the cultivated types of this taxon as *V. unguiculata* cv.-group Unguiculata (the common cowpea), *V. unguiculata* cv.-group Biflora (the catjang cowpea) and *V. unguiculata* cv.-group Sesquipedalis (the yard-long bean).

(7) For the differences between *Phaseolus* L. and *Vigna* Savi see under remarks 2 and 3 of *Phaseolus* L.

(8) Pod types found in the Ethiopian material.

(a) Pods large, pendent, (10.0–)15.0–20.0(–25.0) cm long, (8–)10(–12) mm wide (cv.-group Unguiculata) (WP 7924, WP 7949, WP 7955, WP 7964, WP 8576, WP 8579, WP 8642, WP 8685 and WP 8686).

(b) Pods intermediate, young pods erect, spreading or pendent, mature pods pendent, (11.0–)12.0–15.0(–18.0) cm long, 7(–9) mm wide (cv.-group Unguiculata, and crosses between cv.-group Unguiculata and cv.-group Biflora) (WP 667, WP 2328, WP 7967, WP 7970, WP 8682–WP 8684).

(c) Pods small, young and mature pods as a rule erect or spreading, dry, mature pods often pending, (8.5–)10.0–12.0(–14.0) cm long, 5(–6) mm wide (cv.-group Biflora) (WP 8573, WP 8580, WP 8583, WP 8592, WP 8594, WP 8596, WP 8637, WP 8639, WP 8646, WP 8679, WP 8680, WP 8681).

The erect or pendent position of the pods is not always a clear-cut characteristic and may be not that important. Any conclusive evidence concerning this problem falls outside the scope of this study.

(9) Seed types found in the Ethiopian material.

(a) Seeds large, ± square, sometimes rounded, 7–8(–9.5) × 6–8 mm, light–dark brown; pods pendent, ca 15.0–20.0 cm long and ca 10 mm wide. I designate this taxon as cv. Argobba Giant (S1 172 A, WP 8686).

(b) Seeds idem; pods pendent, ca 10.0–15.0 cm long, less than 10 mm wide. I designate this taxon as cv. Ras Makonnen (S1 343, WP 8691, WP 8682).

(c) Seeds idem, light brown with (dark) violet mosaic. I designate this taxon as cv. Midaga Mosaic (J. J. de Wilde 7292B).

24. Verdcourt distinguishes ssp. *mensensis* within *V. unguiculata* (Kew Bull. 24: p. 545 (1970)). This segregation seems premature since 'it is similar in every way to ssp. *dekindtiana*, except the calyx-lobes much longer than the calyx-tube' (F.T.E.A.: p. 646 (1971)). Verdcourt stated also that 'in the past great value has been placed on calyx-lobe length as a character for separating species of *Vigna*, but it seems to be of very little value and if used separates taxa which are obviously extremely closely related' (l.c. p. 646). Moreover, Verdcourt (1970) did not examine 'any authentic material' of *Vigna mensensis* Schwfth. Seeing that the length of the calyx-lobes of ssp. *mensensis* varies between 0.5–1.4 cm (Verdcourt, l.c. p. 545) and as there are 'numerous intermediates which are not easy to classify' (Verdcourt, l.c. p. 646), while ssp. *mensensis* interbreeds freely (teste Verdcourt) it seems difficult to adopt Verdcourt's ssp. *mensensis*.

(d) Seeds idem, white with a brown ring around the hilum. I designate this taxon as cv. Brown Eye (Sl 1516).
(e) Seeds small, ± square to oblong, 6–7.5 × 5–6.5 mm, red; pods pendent or spreading, young pods possibly erect. I designate this taxon as cv. Red Harar (WP 2555F, WP 7939, WP 8580, WP 8581).
(f) Seeds idem, (5–)6–7(–8.5) × 5–6.5 mm, light brown; pods pendent or erect, young pods erect. I designate this taxon as cv. Gidole (WP 3231D, WP 7965–WP 7967). WP 2554B has smaller and more rounded seeds, whereas WP 3186i has longer seeds. Both are included in this seed type.
(g) Seeds idem, (6–)7(–9) × 5–6 mm, black; pods erect or spreading–pendent, young pods erect. I designate this taxon as cv. Black Lady (WP 3381, WP 7968–WP 7970).
(h) Seeds idem, oblong, 5.5–6(–7.5) × 4–5 mm, light brown with brown mosaic or brown with light brown mosaic; pods as a rule erect or spreading, young pods erect. I designate this taxon as cv. Babile Mosaic (WP 3186C, WP 7958, WP 8593, WP 8594).
(i) Seeds idem, oblong, (5–)6–7(–8) × 4–5 mm, light brown with greyish and/or violet mosaic; pods as a rule erect, young pods erect. I designate this taxon as cv. Empress Menen (WP 3186B, WP 7956, WP 8591, WP 8592).

(a), (b), (c) and (d) belong to cv.-group Unguiculata; the rest to cv.-group Biflora or are possibly crosses between cv.-group Unguiculata and cv.-group Biflora.

All the above listed seed types are found in mixtures at the market places. Moreover, the different seed types (and pod types as well) are grown intermixed in the same field. Consequently hybridization is common and intermediate pod and seed types are found between cv.-group Unguiculata and cv.-group Biflora.

Cv.-group Unguiculata has been found by the author only in the region of Harar.

(10) The following differences were found between plants raised at Wageningen and in Ethiopia.

	Petiole	Rachis	Leaflet length	width	Peduncle
Grown at Wageningen	3.5–25.0 cm	1.5–6.5 cm	6.5–19.5 cm	4.0–17.0 cm	4.0–32.0 cm
Grown in Ethiopia	6.5–12.0 cm	1.5–3.5 cm	6.5– 9.5 cm	3.5– 7.5 cm	11.0–21.0 cm

(11) The description is based on the following specimens.

Wollo	Bati market: WP 4019A–WP 4019F, Sl 1041; Dese market: Sl 1106B; Haik market: Sl 46, Sl 1132; Kombolcha market: Sl 969.
Shoa	Nazret market: WP 2996B, WP 2996C, WP 2997A–WP 2997C; Langano market: WP 2592J; Robi market: Sl 27, Sl 1151.
Wellega	55 km past Nekemte on Gimbi road, Shankalla market: WP 3381.
Illubabor	sin. loc.: Sl 1516, Sl 1540.
Kefa	Bonga market: WP 5538D, WP 5538E.
Gamu Gofa	Gidole market: WP 3231A, WP 3231B, WP 3231D; Giarso market: WP 3221A, WP 3221B, WP 3223B, WP 3223E–WP 3223G; Hogo (Mursi), Lower Omo valley: Turton 32 (K!).

Hararge	Asbe Teferi market: SI 1; Gelemso market: SI 618, SI 619; Alemaya market: WP 3032N, WP 3032R; garden Alemaya: WP 296–WP 299, WP 301, WP 307–WP 310, WP 315, WP 317–WP 319, WP 326–WP 329, WP 331, WP 332, WP 752, WP 753, WP 3179A–WP 3179D; 1.5 km past College entrance on Kombolcha track, in field: WP 2342; idem, 2.5 km: WP 2345; idem, 3.5 km: WP 2347; idem, 4 km: WP 667; Harar market: WP 84L, WP 86A–WP 86D, WP 86F, WP 92A–WP 92D, WP 92F, WP 102A, WP 102C, WP 102D, WP 103G–WP 103J, WP 104A–WP 104C, WP 294, WP 2551D, WP 2551E, WP 2551G, WP 2551H, WP 2554A, WP 2554B, WP 2555E–WP 2555i, WP 2556A–WP 2556D, WP 3186A–WP 3186C, WP 3186E–WP 3186G, WP 3186i–WP 3186K, WP 3187A, WP 3187B, WP 3187D–WP 3187G, WP 3188A–WP 3188D, WP 3188F, WP 3189A–WP 3189F, WP 3492D, WP 3492E, WP 3492i, WP 4039A–WP 4039F, WP 5560J–WP 5560N; Feddis market: SI 172, SI 176, SI 190; ± 10 km on track (off Harar-Jijiga road) to Mederu village, in field with sorghum: WP 2328; 8 km past Harar on Jijiga road, in field: WP 2357–WP 2359, WP 2361–WP 2364; 14 km past Harar on Jijiga road, in field: WP 2366; Besedimo, compound: WP 2374; Jijiga market: SI 343, SI 354; Midaga market: J. J. de Wilde 7292A–C, J. J. de Wilde 7293A–C, J. J. de Wilde 7294; Godie on Webi Shebele: Taddesse Ebba 816 (K!).
Grown at Wageningen	WP 5893, WP 5901–WP 5906, WP 5912, WP 5927–WP 5932, WP 5953, WP 5955–WP 5957, WP 5963, WP 5969, WP 5970, WP 5975, WP 5976, WP 6293–WP 6296, WP 6299–WP 6301, WP 6401–WP 6403, WP 6887–WP 6890, WP 7128, WP 7923–WP 7931, WP 7935–WP 7980, WP 8571–WP 8573, WP 8575–WP 8583, WP 8591–WP 8596, WP 8636–WP 8642, WP 8645, WP 8646, WP 8679–WP 8688, WP 8690–WP 8692.

Ecology

The cowpea may be regarded as a short-day plant; only one of the cultivars included in Wienk's experiments clearly showed an ambi-photoperiodic reaction (1963). Stanton et al. (1966) distinguish between cultivars of 'the short-day type' and those of 'the early-stimulus short-day type', which is not completely dominant and in which the long-day effect can be overcome by short days during the early periods of growth. These differences in day length are highly significant in causing flower production, and have resulted in a range of cultivars, each adopted to local agronomic and climatic conditions. If flowers are removed, either mechanically, or by insect infestation, the flowering period is extended, and it has been found that complete insect control alters the supposed development pattern of a particular cultivar, so that, e.g., a good pod set accelerates maturity (Stanton et al., 1966).

Cowpeas can be grown under a wide range of conditions. They are sensitive to cold and are killed by night frost, but tolerate heat and relatively dry conditions but suffer from heavy drought and can be grown with less rainfall and under more adverse conditions than *Phaseolus vulgaris* and *P. lunatus*. The yard-long bean can tolerate and requires a higher rainfall than the other cultivar-groups. Cowpea is adapted to a great variety of soils, provided they are well-drained. They are sometimes grown on very poor acid soils as a soil improver (Purseglove, 1968).

To obtain an optimum seed yield, Wienk (1963) suggested to sow at such a time of the year that a fairly long vegetation period may be expected, i.e. during relatively long days. This would imply an increase in dry matter production and subsequently higher seed yield owing to the effect of long days on leaf area and time of flowering. However, when the vegetative period becomes too long, seed yield may decrease in spite of increased total dry matter production.

Husbandry

In Asia and Africa cowpeas are mainly grown in small areas around homesteads, often interplanted with other food crops such as cassave, yam, maize, sorghum and bulrush millet, but they are also found in pure stand. Tillage normally follows the crop with which the cowpea is interplanted. The seed is then broadcast at a rate of 20–40 kg/ha. Later on the field is thinned, the removed plants are used as pot herbs, and after the second or third weeding the mutual distance of the plants is up to 2 × 2 m. The distance in early plantings depends on the cultivar. Under mechanized conditions, the 60-day maturing upright cultivars are planted at 15–25 cm in the row, the rows 75–90 cm apart. The more vigorous later maturing types are planted at double this distance in the row. The agronomic disadvantage of early planting is that the crop matures at the same time as the early cereal (maize, millet), thus increasing the peak in labour demand, which is not so with late cowpeas that are harvested after the harvest of the cereals (Stanton et al., 1966).

In the southern U.S.A., cowpeas are usually grown in rotation with cotton and maize. When grown for dry seed production, a spacing of 75–90 × 5–8 cm is used with a seed rate of ± 15–30 kg/ha. For forage production in the U.S.A. the crop is usually grown mixed with Sudan grass, sorghum or maize. A wider spacing is required for creeping than for more or less erect cultivars. Cowpeas are usually grown as a rain-fed crop, but are sometimes irrigated in California (Purseglove, 1968). In India they are grown as an early or late rainy season crop (both pure and mixed), or as a dry season crop under irrigation (special cultivars). For seed, cowpeas are sown in rows 90 cm apart; for forage, broadcast or sown in rows 15–20 cm apart. In Zanzibar, they are grown in rotation with rice and turned in (Whyte et al., 1953).

Early cultivars are sown at the beginning of the rains, especially at the first rains in the two-peak rainfall areas, or as an irrigated crop. Late cultivars are sown towards the end of the rains, at the beginning of the second rains or even towards the end of the second rains in soils with a high moisture capacity or under conditions in which the water table recedes slowly, such as near Lake Chad. While some of the most vigorous types of cowpea can compete successfully with grassy weeds, early clean weeding is important to reduce leaf diseases and nutrient competition, and to decrease the competing moisture demand for weed growth later on (Stanton et al., 1966).

Early maturing cultivars produce a crop in about 3 months and green pods may be picked after 50 days. Late cultivars may take up to 5 months to mature (Purseglove, 1968). The pods tend to ripen unevenly and if left too long on the plant they are

likely to shatter, at least in some cultivars. Therefore, these are handpicked now and then and stored. Sometimes the plants are pulled out when most of the pods are mature (Krishnaswamy, in: Kachroo, 1971). For hay, the crop is cut when most of the pods are well-developed.

The plant is extensively grown as a vegetable crop (cv.-group Sesquipedalis) and then receives greater attention in the preparation of the seed bed, manuring, irrigation, etc. (Krishnaswamy, in: Kachroo, 1971).

In the tropics yields of (<330–)450–675 kg/ha of dry beans are obtained; in the U.S.A. yields of dry beans amount to 1100–1700 kg/ha, with up to 2800 kg/ha of black-eye beans in California. Hay production is about 5 tons/ha (Purseglove, 1968).

Cowpeas are susceptible to many pests and diseases, including viruses, which is especially important for cultivars grown under circumstances for which they have not been selected. The plant is undoubtedly one of the most important crops, in view of its present contribution to and as potential supplier of human and stock food throughout the savanna zones of Africa (Stanton et al., 1966). According to Sellschop (1963) cowpeas would probably have been even more important if the damage caused by insects and certain nematodes (*Meloidogyne* spp.) could be kept within reasonable limits.

In Ethiopia cowpeas are mainly grown in the drier regions (Hararge, Konso, and probably Eritrea). In the Konso region they grow together with the other crops and are sown at the onset of the main rains at the beginning of March, and harvested with the other bean crops around August. In the area south-east of Harar, cowpea is intersown with sorghum at the end of the main rains in September and harvested around December. It is found up to 2000 m altitude.

Uses

Cowpeas are used for human food, as concentrate for farm animals, hay, silage, pasture, soil cover, green manure, etc. The young leaves and shoots are consumed as a spinach and provide one of the most widely used pot herbs in tropical Africa; they are often dried and stored for dry-season use. The value as a pot herb is due to the fact that cowpeas do not mature in a definite period, but continue to produce new leaves if cut back regularly from an early stage on (Purseglove, 1968). In India, the leaves are also used in dyeing to obtain a green dye; for this purpose they are mixed with *Strobilanthes flaccidifolius* Nees and turmeric (Burkill, 1966). The young pods are eaten as a vegetable. Some climbing forms are exclusively grown for their very young, long pods (cv.-group Sesquipedalis), which are cut in sections and boiled. The young seeds are also edible (Burkill, 1966; Terra, 1966). In the U.S.A. the fresh seeds and immature pods are sometimes frozen or canned. Particularly in Africa the dried seeds are important, especially the large white-seeded, quick-cooking cultivars (Purseglove, 1968). These seeds are boiled or roasted. In various countries they are ground into flour which is particularly valued for cakes, etc. (Dalziel, 1937). In India cowpea is used mostly as a pulse, either whole or as dhal, but also as flour, after

husking or with husk (Krishnaswamy, in: Kachroo, 1971). The seeds are sometimes used as a substitute for coffee (Cobley, 1963).

Due to the easy cultivation, cowpea is a useful fodder plant for hay, silage or pasture; it is also used as a green manure and cover crop. Sellschop (1962) supposes that it would have been used far more extensively if vines and foliage were less coarse and if it was not a creeper. The sprawling growth habit makes it necessary for the crop to be gathered by hand, and its coarseness militates against the rapid curing of the hay.

Cowpeas are usually resorted to as a hay or grazing crop when a too low rainfall, or lack of irrigation water does not permit the production of fine-stemmed and easily cured fodder. The best stage for cutting is when the first pods turn yellow. At that stage the leaves and pods still contain over 60% of the original quantity of crude protein and then loss of leaves during drying and handling of the hay is lowest (Sellschop, 1962).

One form, cv.-group Textilis (syn. *Vigna sinensis* var. *textilis* A. Chev.)[25], is grown in northern Nigeria for its strong fibre obtained from the erect peduncles, which are up to 60 cm long. The bark of the stem is not suitable for this purpose. The seeds of this taxon are not eaten (Dalziel, 1937).

Several of the wild forms of *Vigna unguiculata* are occasionally used in times of scarcity (Dalziel, 1937).

In Ethiopia cowpea seeds are used in 'wot", or ground into flour for the preparation of various foods. The Chako in south-west Ethiopia eat the leaves as a spinach (Cufodontis, 1957; Straube, 1963).

Protein content

Leaves: 2–5.3% (Terra, 1966); young pods: 3.4% (Purseglove, 1968), 2–4.3% (Terra, 1966); older pods: up to 9% (Terra, 1966); young seeds: 4.5–5% (Terra, 1966); ripe seeds: 26.9% (Busson, 1965), 19–24% (Chevalier, 1944), 23.4% (Purseglove, 1968), 19–23% (Sellschop, 1962), 24% (Terra, 1966); bean sprouts: 5% (Terra, 1966).

From the few studies made so far the biological value of cowpeas appears to be rather low. This may be attributed to an unbalance of amino acids, particularly a deficiency of methionine (Sellschop, 1962). However, according to Aykroyd & Doughty (1964), no limiting amino acid is involved.

25. Var. *textilis* of *Vigna sinensis* is reduced to the status of cv.-group, since it is, in essence, a collection of cultivars. No further attention, however, is given here to this taxon.

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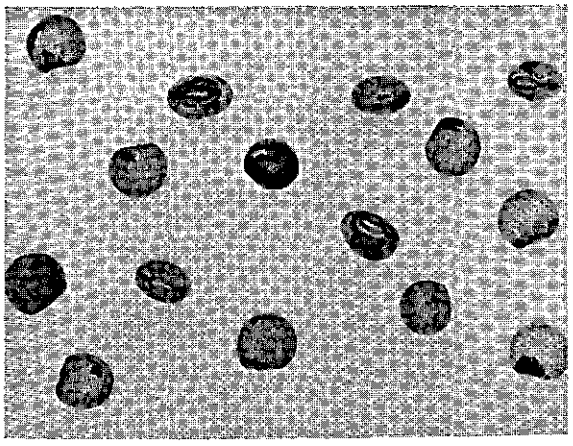

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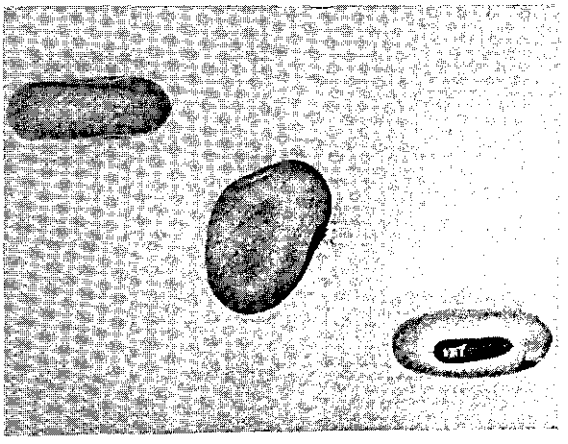

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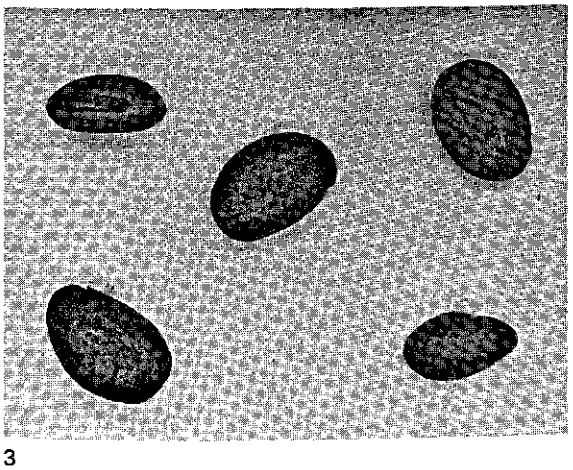

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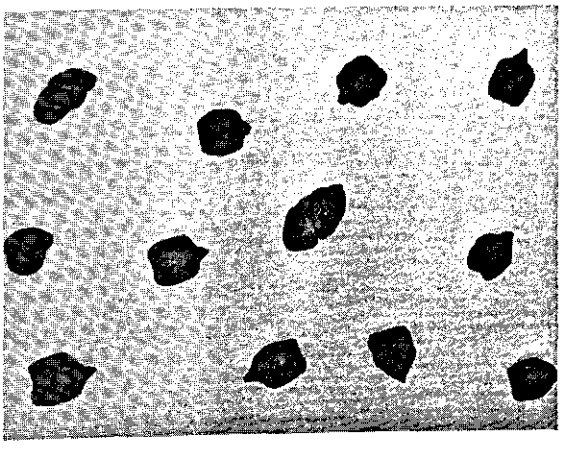

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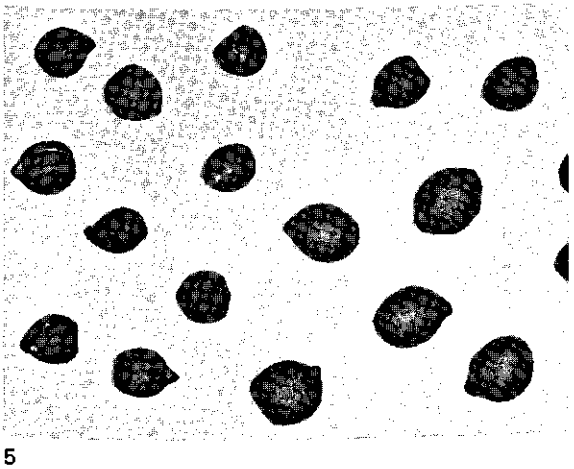

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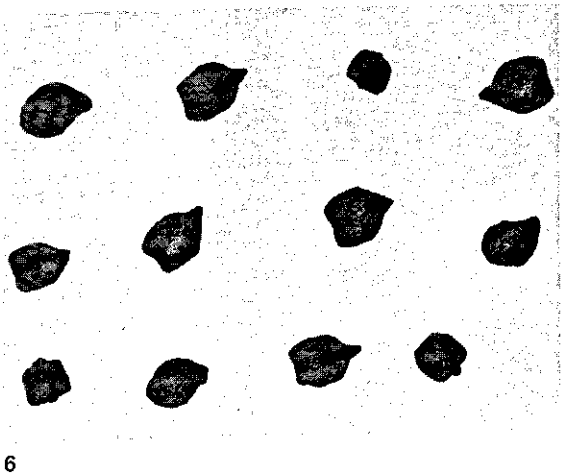

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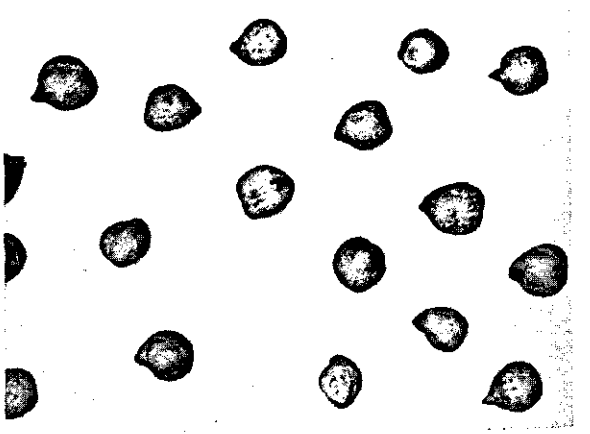

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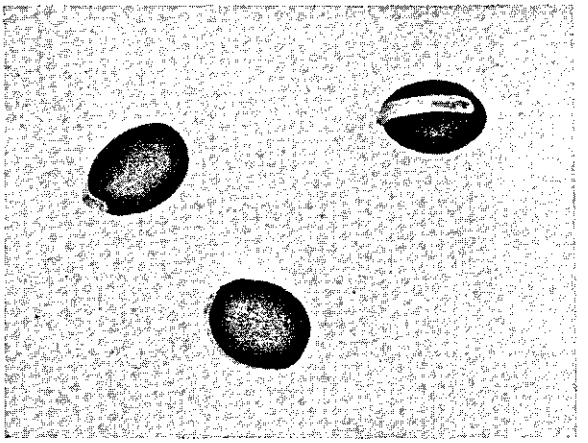

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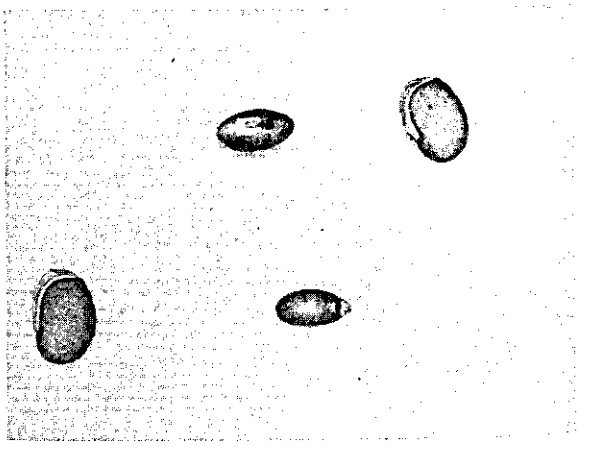

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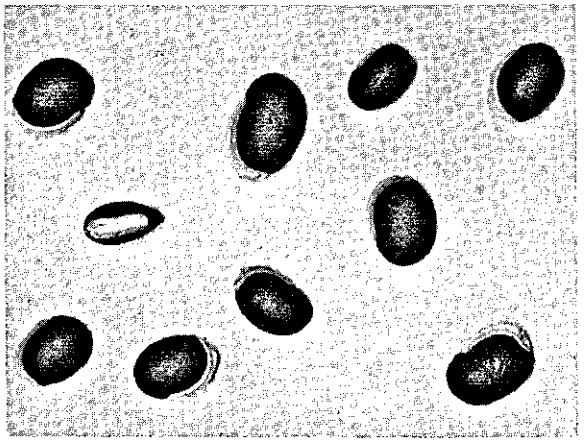

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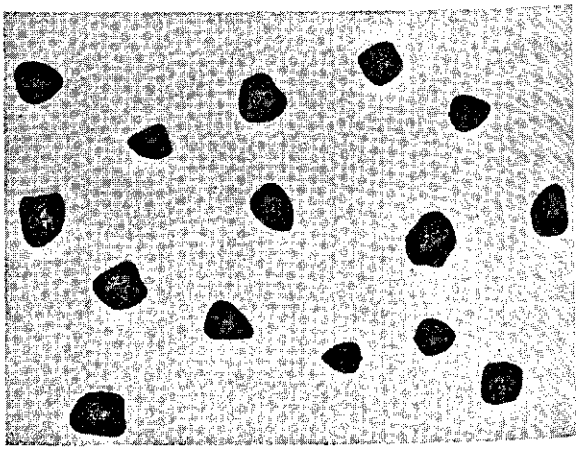

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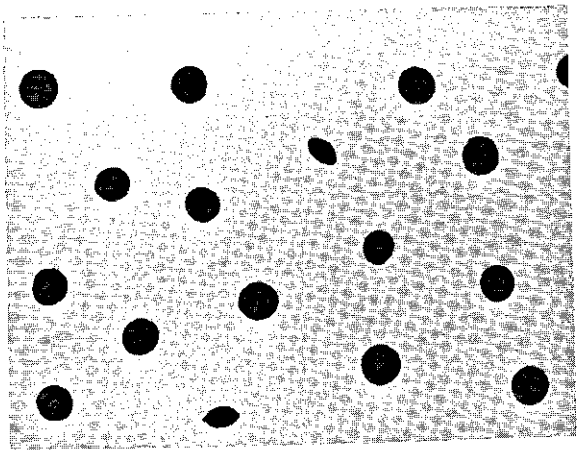

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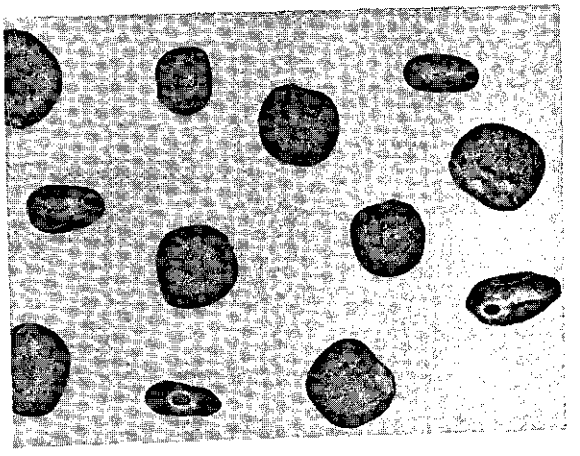

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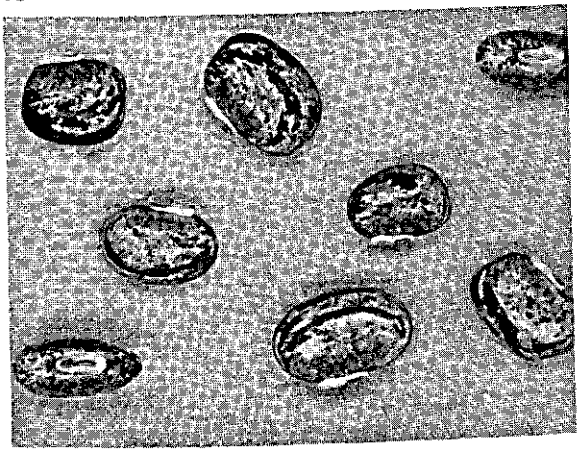

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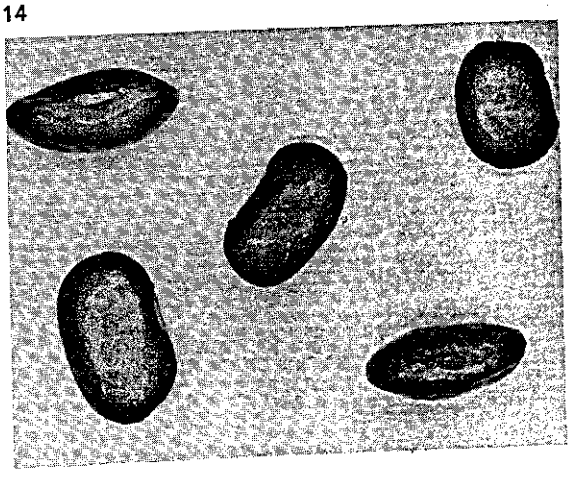

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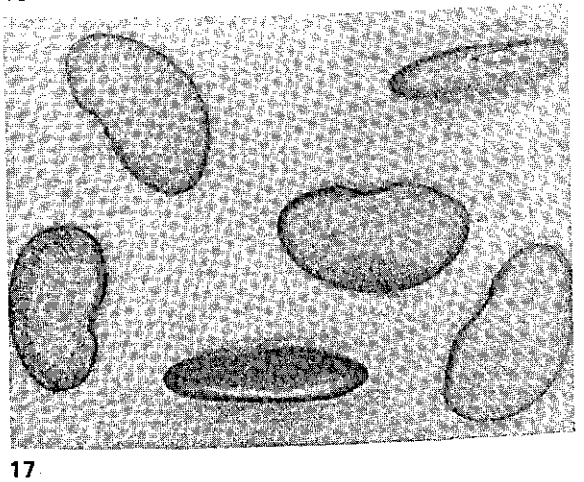

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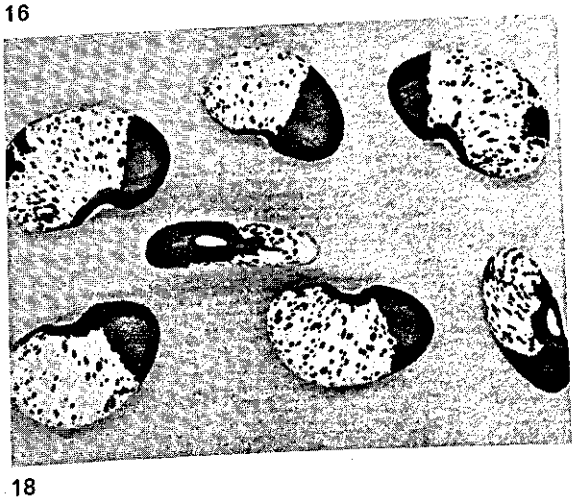

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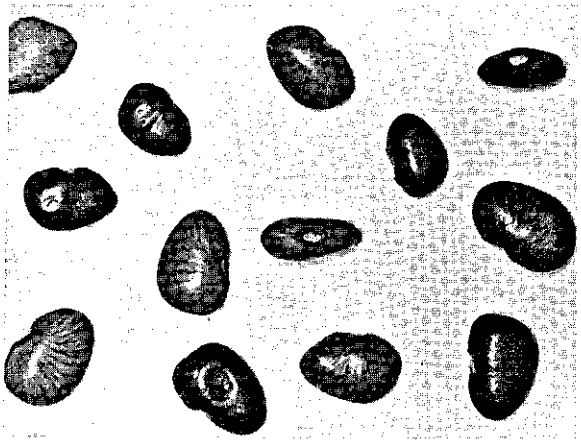

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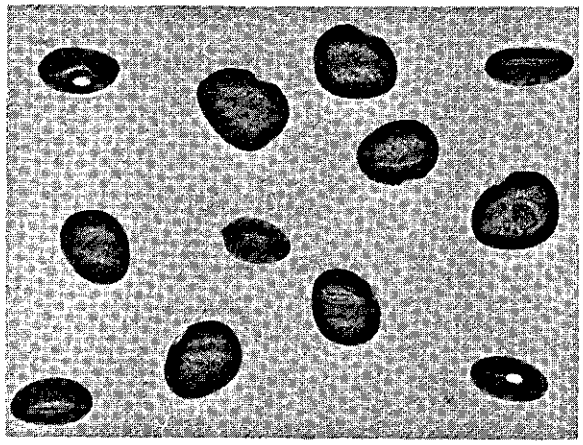

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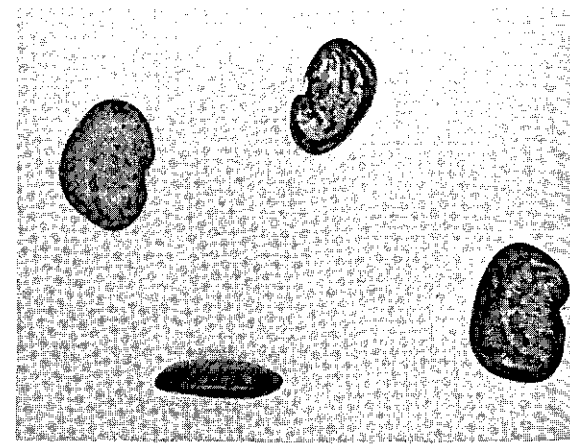

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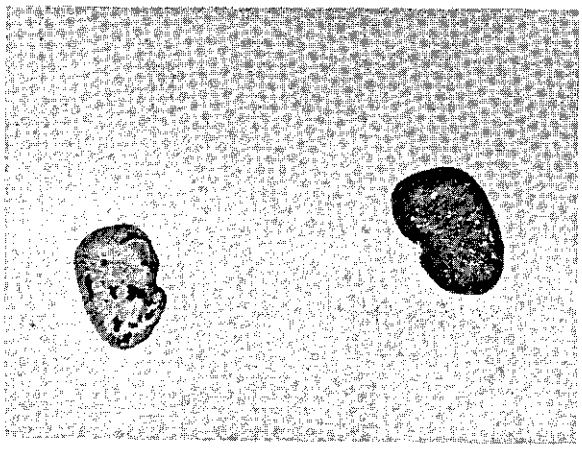

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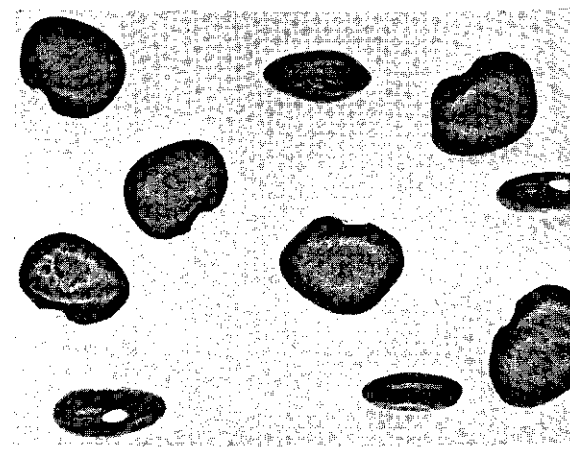

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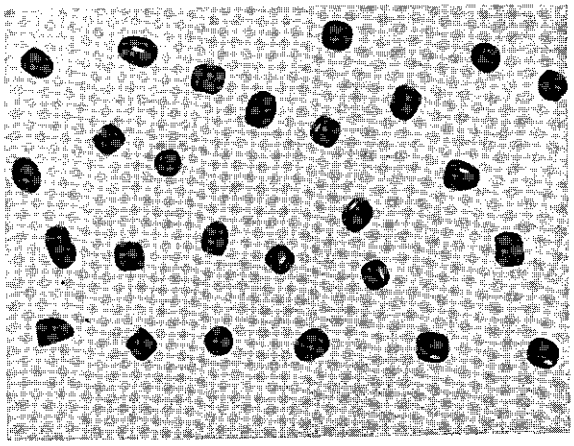

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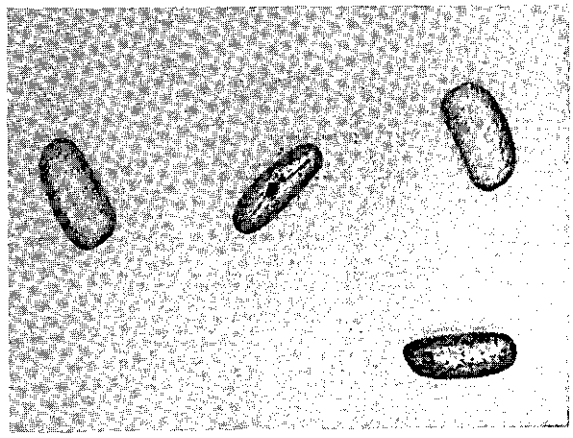

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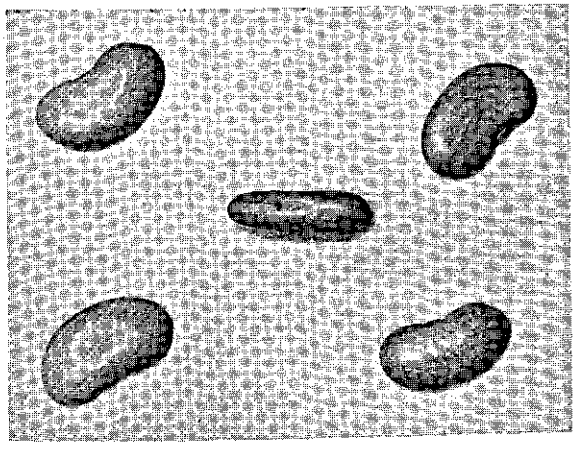

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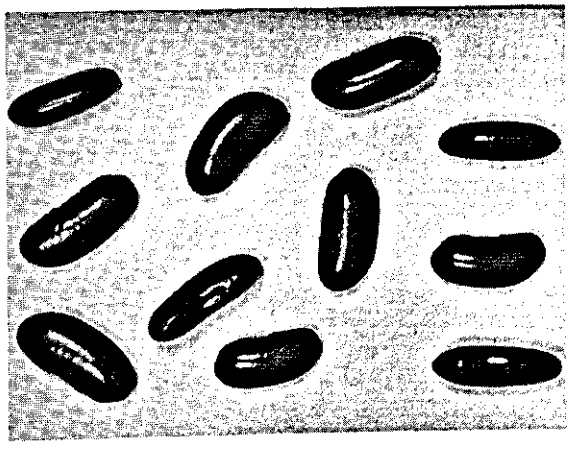

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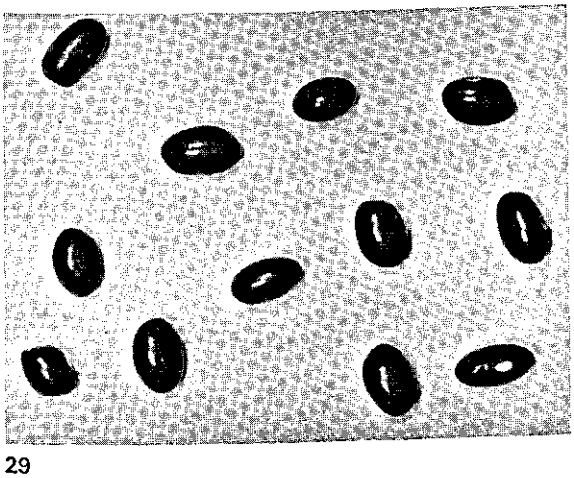

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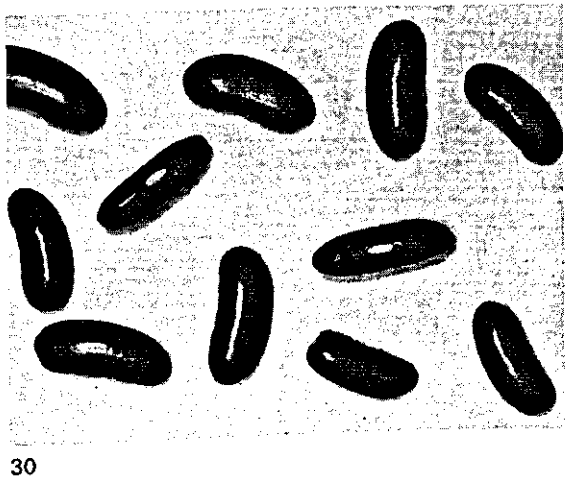

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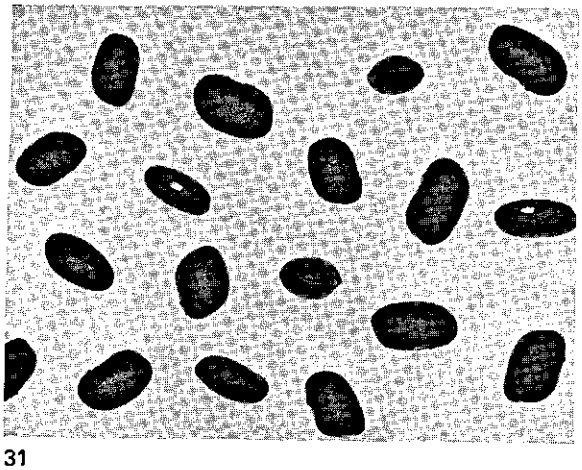
Plate 29. *Phaseolus vulgaris* cv. Purple Bedelle (WP 8464)
Plate 30. *Phaseolus vulgaris* cv. Asella Ebony (WP 3073F)



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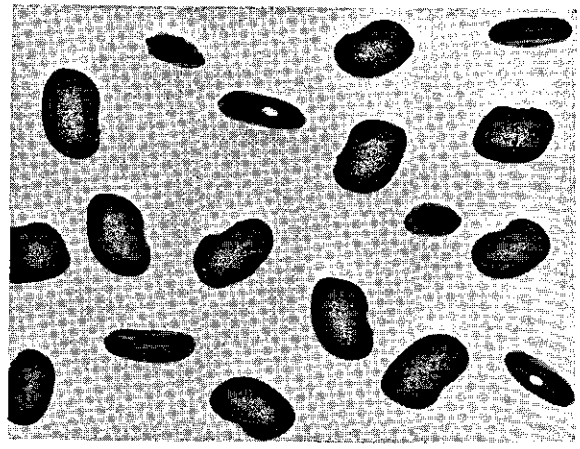

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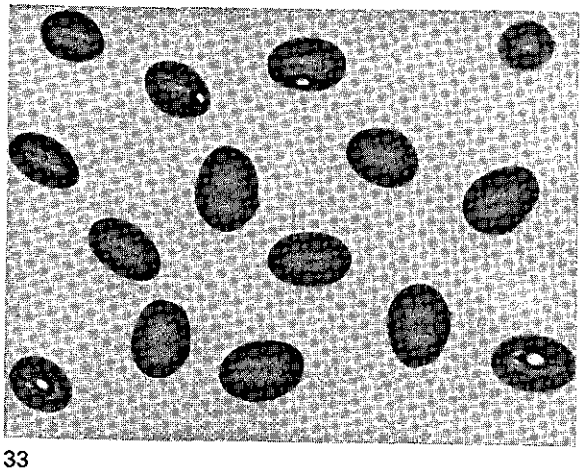

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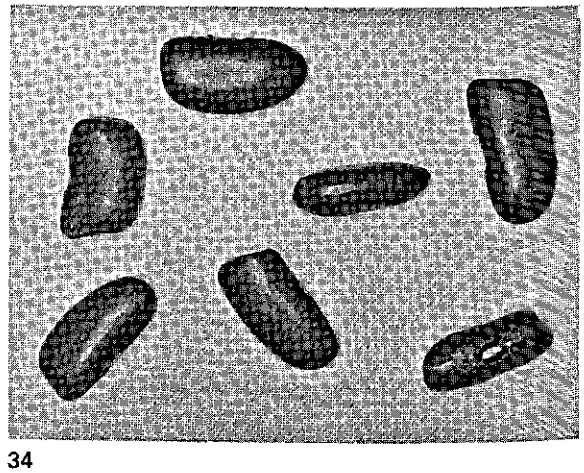

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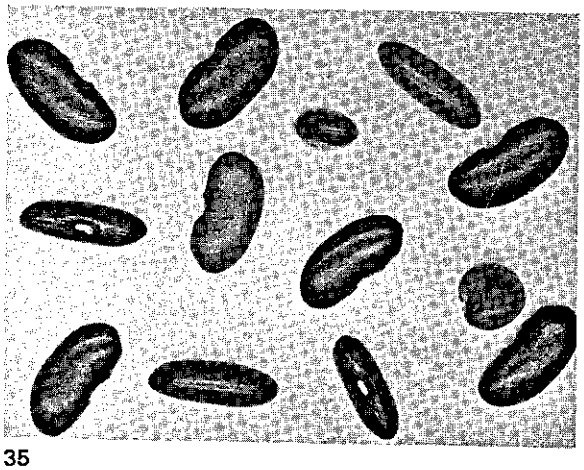

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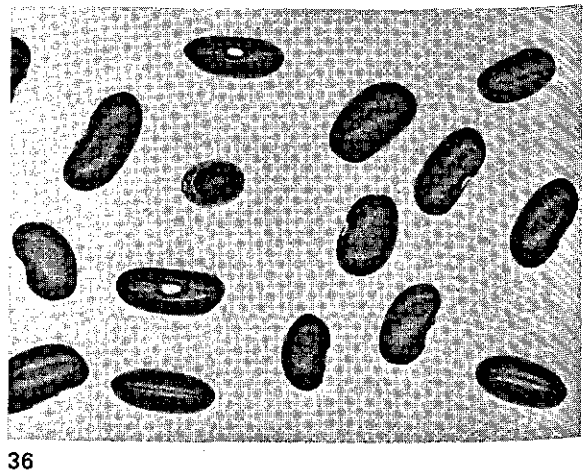

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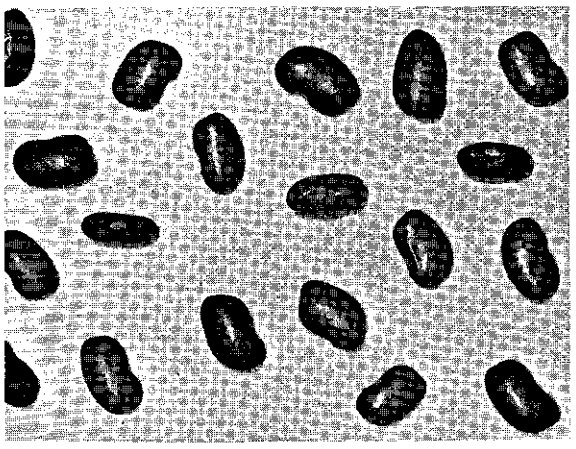
Plate 31. *Phaseolus vulgaris* cv. Black Konso (WP 3223A)
Plate 32. *Phaseolus vulgaris* cv. Black Konso (WP 5538C)
Plate 33. *Phaseolus vulgaris* cv. Pearly Wonji (WP 8232)
Plate 34. *Phaseolus vulgaris* cv. Giant Ebba (WP 5555)
Plate 35. *Phaseolus vulgaris* cv. Giant Eyob (WP 8397)
Plate 36. *Phaseolus vulgaris* cv. Hirna Resort (WP 4007i)



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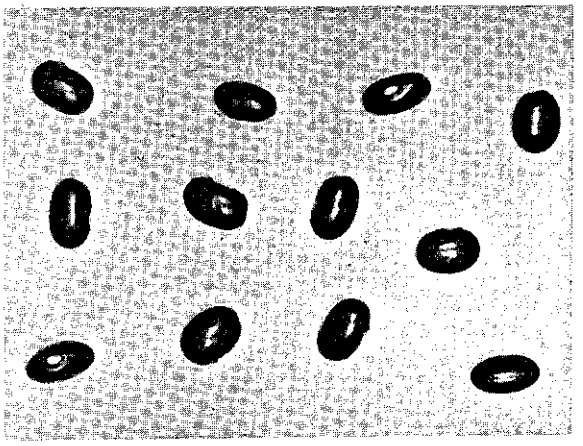

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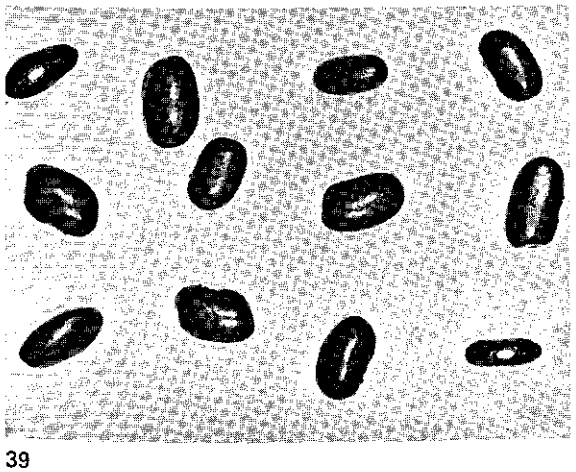

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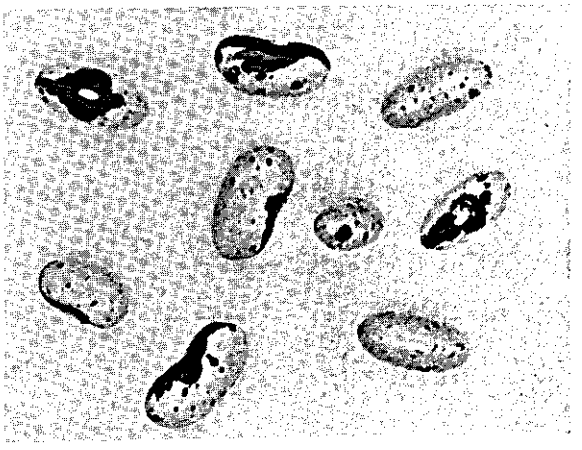

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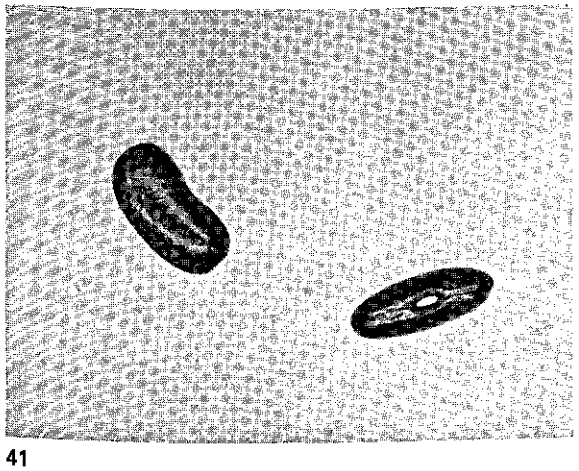

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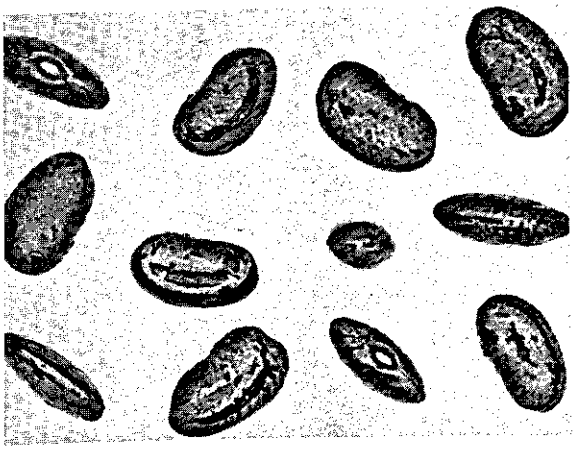

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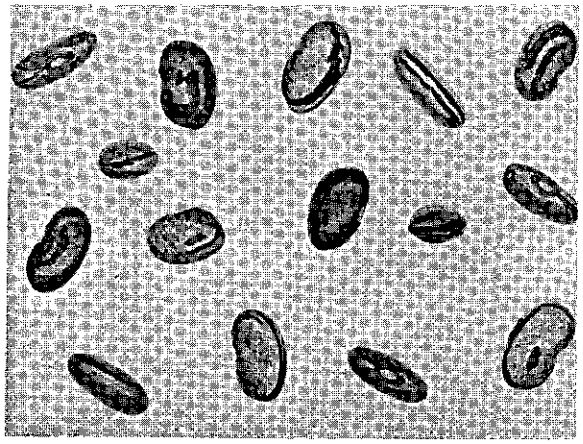
Plate 37. *Phaseolus vulgaris* cv. Brown Buditi (WP 2553H)
Plate 38. *Phaseolus vulgaris* cv. Glossy Wonji (WP 3069J)
Plate 39. *Phaseolus vulgaris* cv. Dawit's Despair (WP 4981A)
Plate 40. *Phaseolus vulgaris* cv. Nazret Mosaic (WP 7316)
Plate 41. *Phaseolus vulgaris* cv. Jima Mosaic (WP 5562)
Plate 42. *Phaseolus vulgaris* cv. Jima Mosaic (WP 8487)



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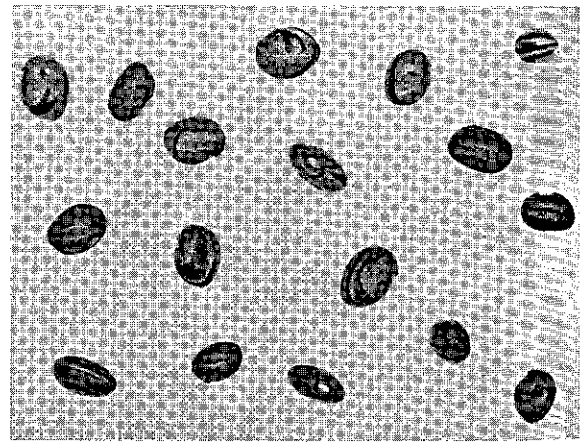

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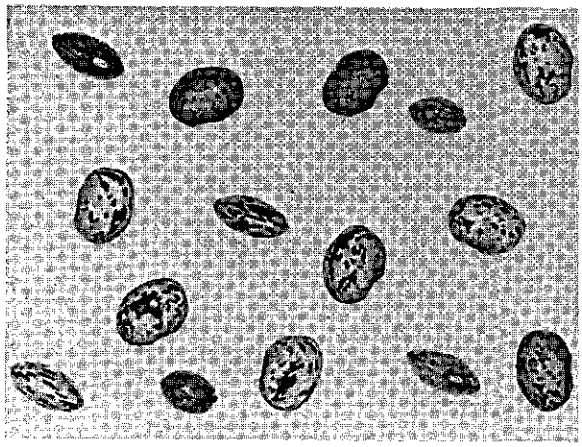

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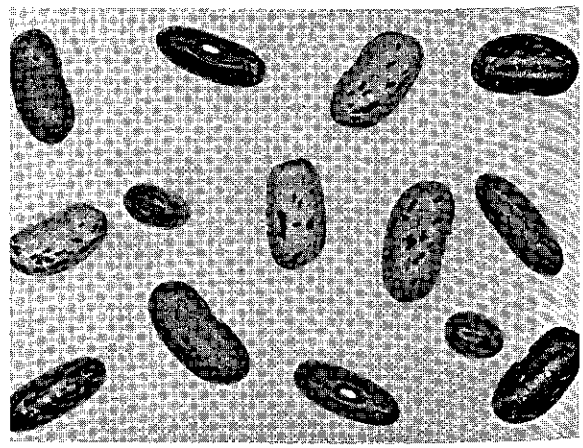

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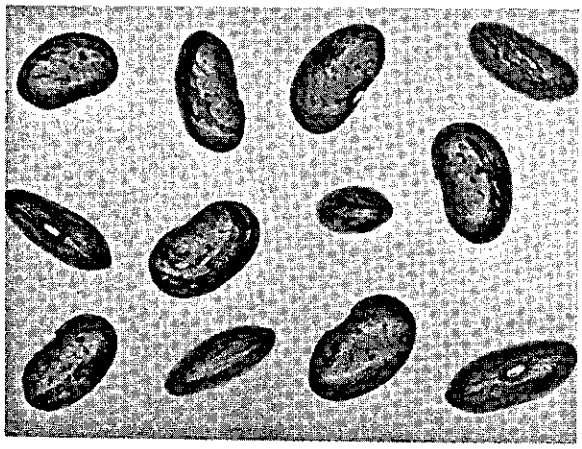

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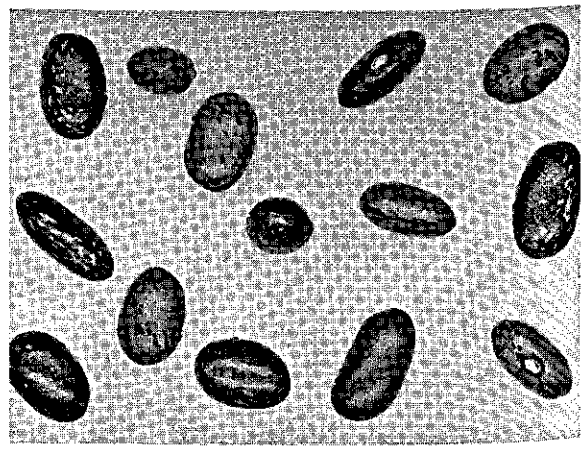

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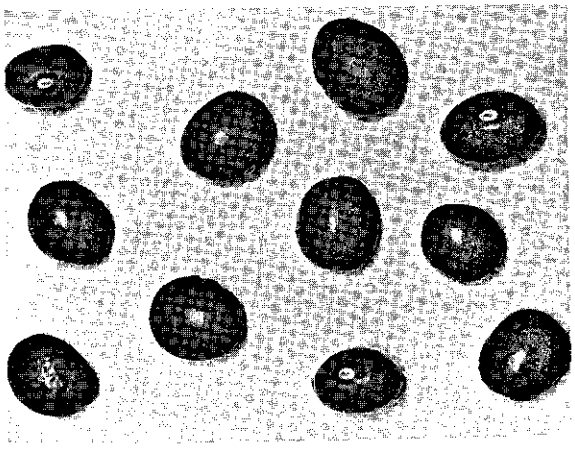
Plate 43. *Phaseolus vulgaris* cv. Bedessa Mosaic (WP 5560E)
Plate 44. *Phaseolus vulgaris* cv. Bedessa Mosaic (WP 7323)
Plate 45. *Phaseolus vulgaris* cv. Langano Mosaic (WP 8121)
Plate 46. *Phaseolus vulgaris* cv. Agaro Mosaic (WP 8089)
Plate 47. *Phaseolus vulgaris* cv. Gergertu Mosaic (WP 8474)
Plate 48. *Phaseolus vulgaris* cv. Gergertu Mosaic (WP 8436)



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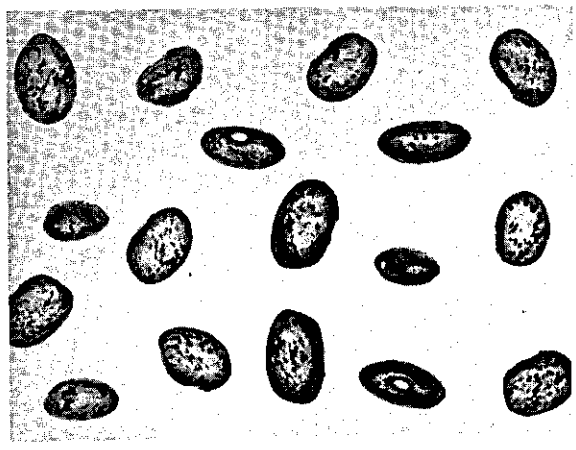

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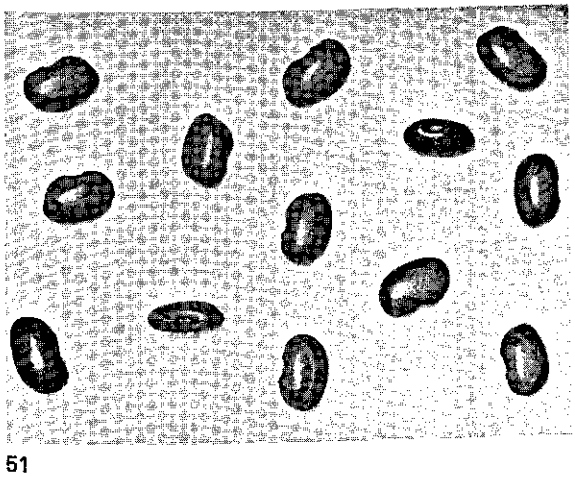

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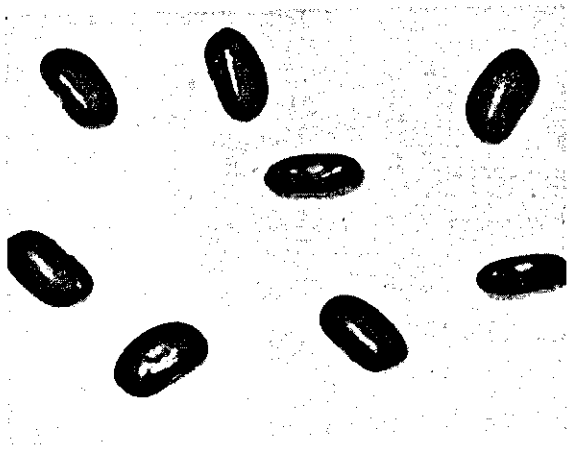

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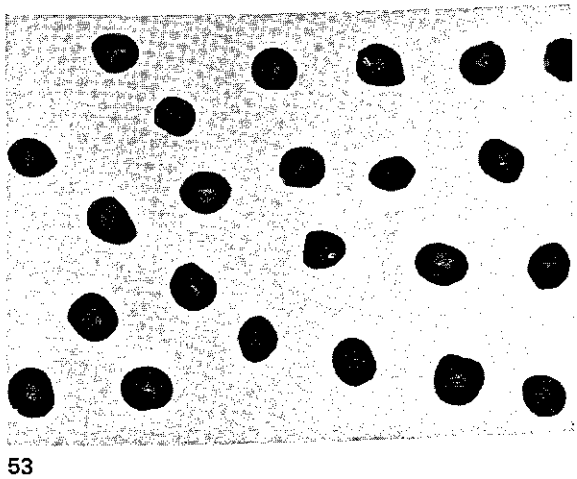

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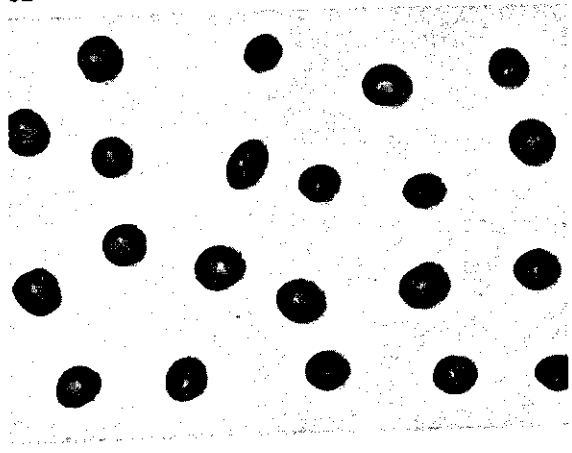

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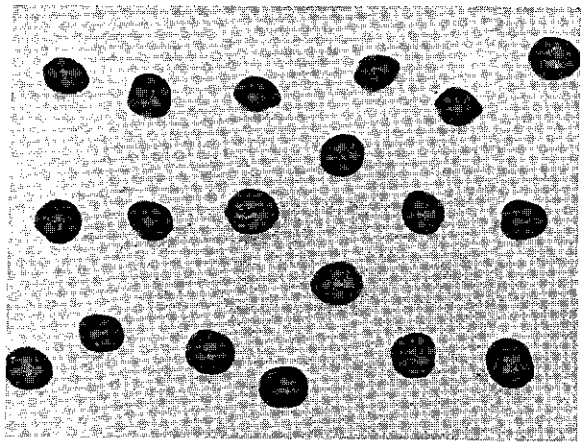
Plate 49. *Phaseolus vulgaris* cv. Pearly Nazret (WP 7326)
Plate 50. *Phaseolus vulgaris* cv. Wonji Mosaic (WP 8244)
Plate 51. *Phaseolus vulgaris* cv. Kurfachelli Mosaic (WP 2480)
Plate 52. *Phaseolus vulgaris* cv. Charming Chercher (WP 2590C)
Plate 53. *Pisum sativum* cv. Vavilovianum (WP 2991A)
Plate 54. *Pisum sativum* cv. Viridulo-Griseum (J. J. de Wilde 7181)



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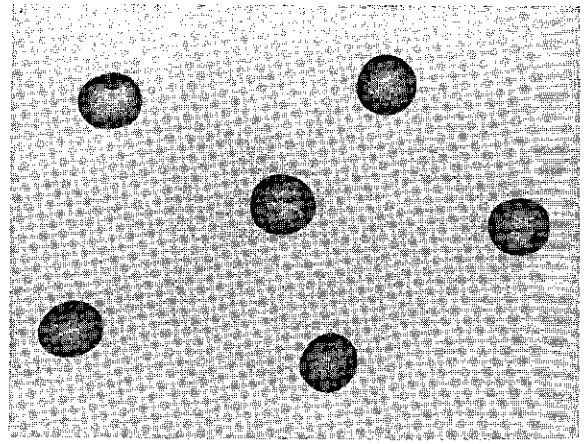

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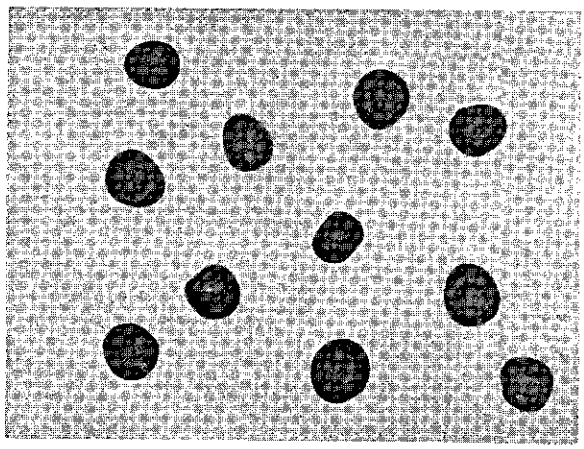

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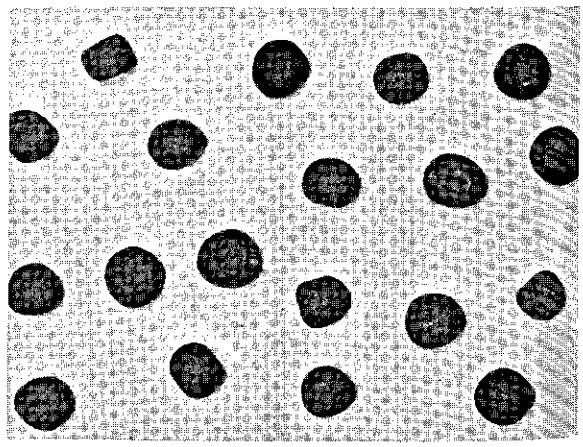

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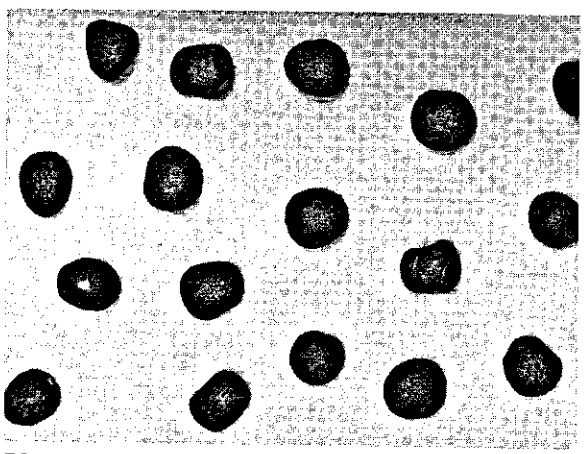

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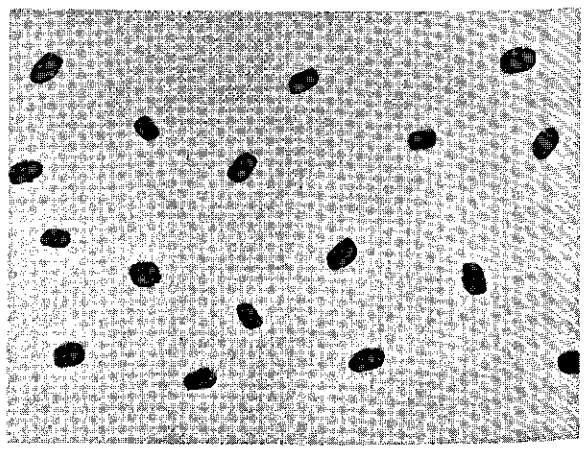

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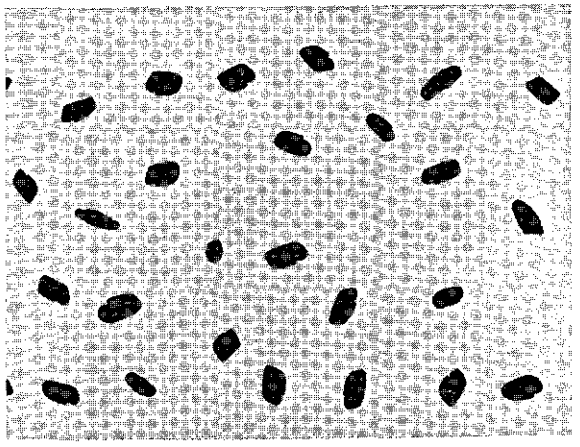
Plate 55. *Pisum sativum* cv. Speckled Jijiga (J. J. de Wilde 7370B)
Plate 56. *Pisum sativum* cv. White Adere (WP 17D)
Plate 57. *Pisum sativum* cv. Addis Abeba (WP 3026B)
Plate 58. *Pisum sativum* cv. Speckled Shoa (WP 4904E)
Plate 59. *Pisum sativum* cv. Wolliso Marble (WP 7825A)
Plate 60. *Trigonella foenum-graecum* cv. Aduan Victory (WP 4974)



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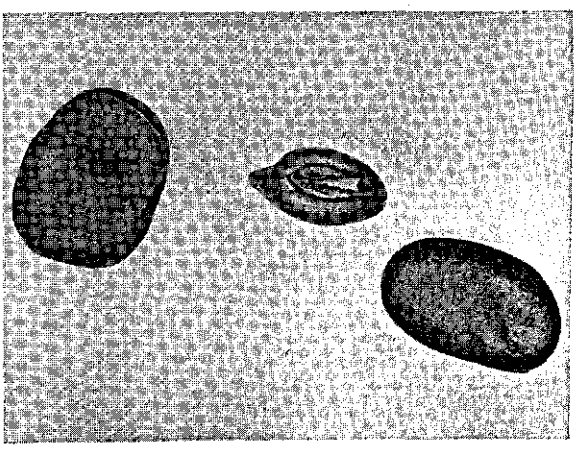

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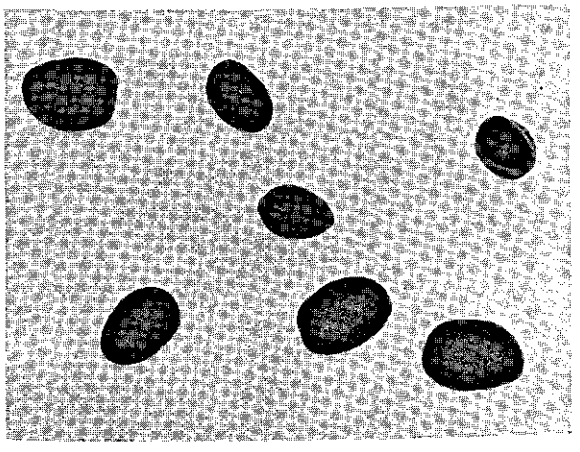

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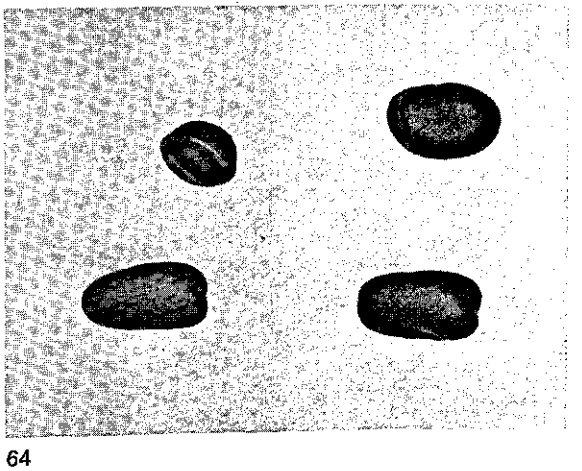

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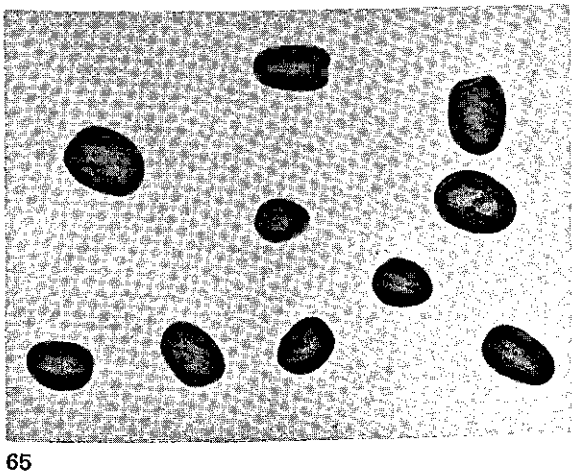

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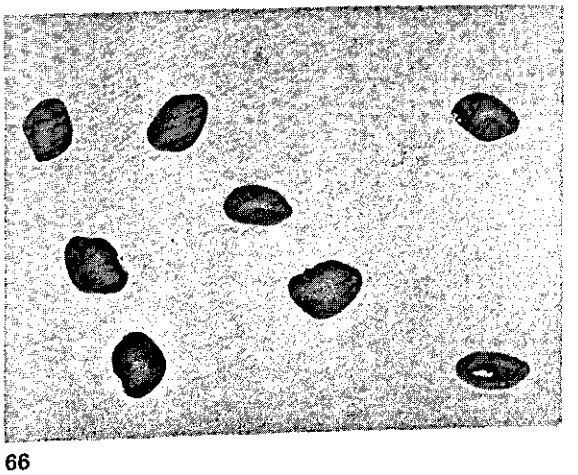

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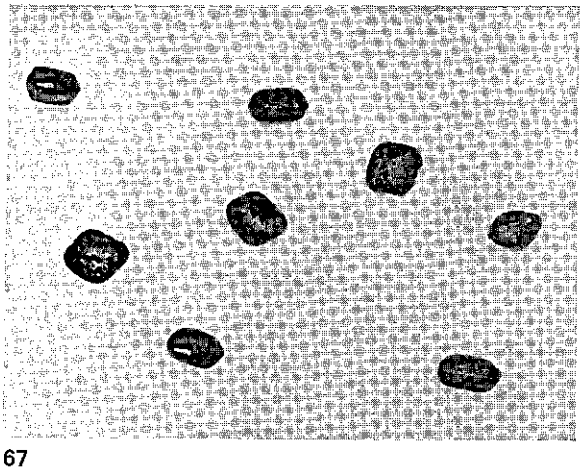
Plate 61. *Trigonella foenum-graecum* cv. Debre Birhan (WP 5564A)
Plate 62. *Vicia faba* cv. Giant Dawit (WP 4058A)
Plate 63. *Vicia faba* cv. Abyssinica (WP 2983C)
Plate 64. *Vicia faba* cv. Abyssinica (WP 3255A)
Plate 65. *Vicia faba* cv. Glossy Makonnen (WP 2817A)
Plate 66. *Vigna unguiculata* cv. Argobba Giant (WP 2556B)



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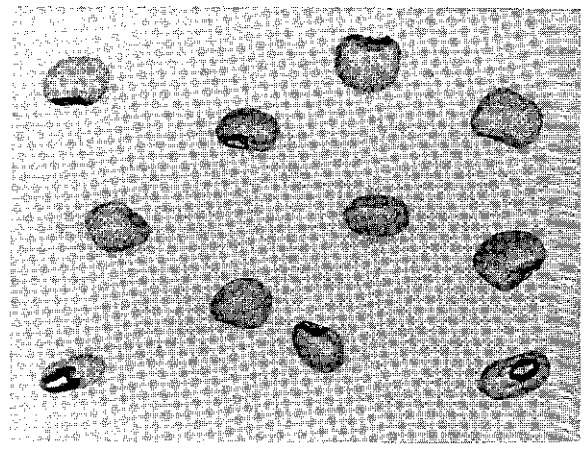

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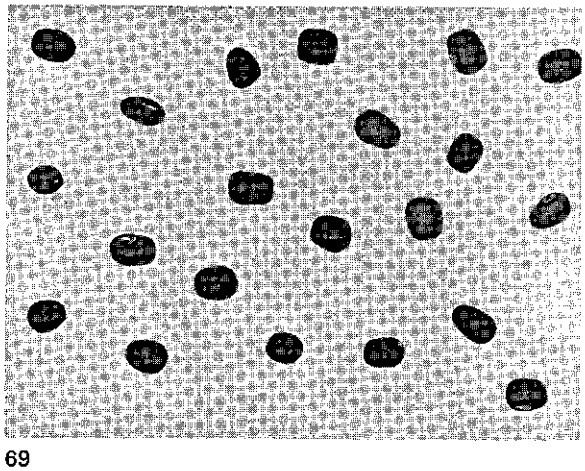

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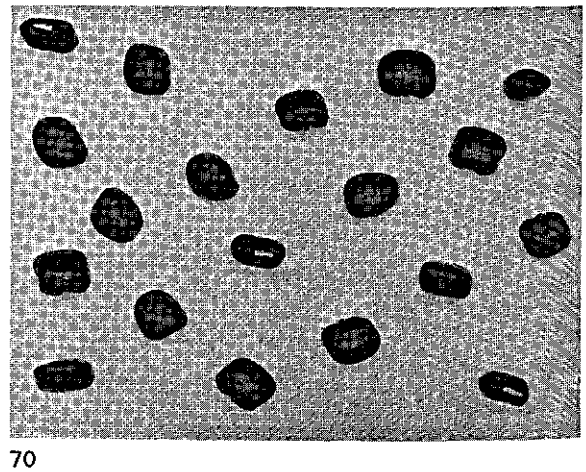

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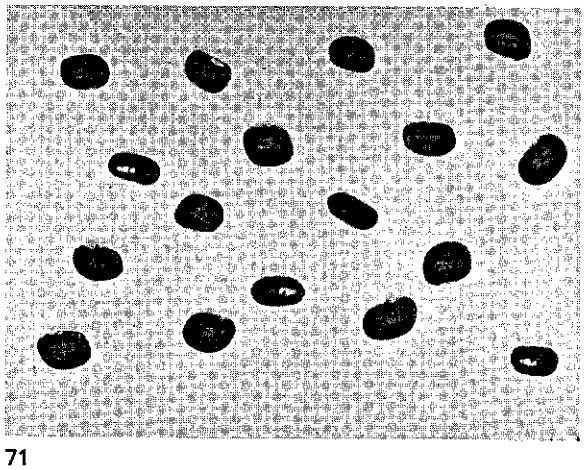

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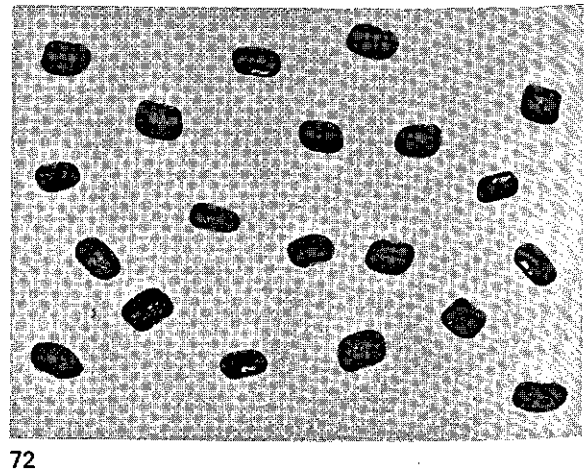

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Plate 67. *Vigna unguiculata* cv. Midaga Mosaic (J. J. de Wilde 7292B)
Plate 68. *Vigna unguiculata* cv. Brown Eye (SI 1516)
Plate 69. *Vigna unguiculata* cv. Gidole (WP 2554B)
Plate 70. *Vigna unguiculata* cv. Red Harar (J. J. de Wilde 7293B)
Plate 71. *Vigna unguiculata* cv. Black Lady (WP 3381)
Plate 72. *Vigna unguiculata* cv. Empress Menen (WP 2556D)