Greenhouse Horticulture in China: situation and prospects

report on a study tour 11 October - 2 November 2003

Editors-in- Chief:
J. Miguel Costa and Ep Heuvelink

Co-Editor
Niek Botden

Authors:
Niek Botden (MSc.)
Susana M.P. Carvalho (Ph.D.)
J. Miguel Costa (Ph.D.)
Ep Heuvelink (Ph.D.)
Oliver Körner (Ph.D.)
Anke van der Ploeg (MSc.)

Horticultural Production Chains Group
Wageningen
March, 2004

1st print: 150 copies

Cover design: Oliver Körner
Photographs: Niek Botden, Miguel Costa, Oliver Körner, Susana Carvalho

Greenhouse horticulture in China : situation and prospects
(report on a study tour 11 October-2 November 2003

March 2004
ISBN 90-6754-744-1
Horticultural Production Chains Group
Department of Plant Sciences, Wageningen University and Research Centre
Marijkeweg 22, 6708 PG Wageningen
The Netherlands

Tel: + 31 317 484096
Fax: + 31 317 484709
E-mail: ep.heuvelink@wur.nl (contact address)
E-mail: miguel.costa@wur.nl
E-mail: niek.botden@wur.nl

Printed by Ponsen & Looijen BV, Wageningen

Preface

About 4 years ago a group of Ph.D. students from our Horticultural Production Chains group visited Spain and investigated the Almería area for its horticultural potential. This resulted in a report describing the situation on many different levels (Greenhouse horticulture in Almería (Spain) - report on a study tour 24-29 January 2000). From basic technical descriptions of the different horticultural practices up to market analyses and assessments of the international position and growth potential. The report was met with interest by the Dutch horticultural community as growers and companies were assessing the possibility of year round production by opening separate production units in Almería. It was based on this (success) story that a new attempt was made to a much more ambitious project.

China is considered to be the potential world producer of horticulture with its one billion farmers. Our Ph.D. students and Post-Docs cooked up a plan to take on China's horticulture. First an extensive literature survey on the subject was turned into a written report. Dutch and foreign industry was approached to support the project financially. Also our good connections to fellow scientists of China were of great help. Most of the details for the field trip in 5 regions were prepared by them and they connected us to Chinese industry and institutes which paid for most of the expenses in China. As they were scientists and good long term friends they helped us also with getting the real data of the sector, which would not be easily available otherwise. When everything was prepared for the 3 weeks field trip of 6 members of our group in April 2003 the terrible epidemic of SARS broke out and everything had to be postponed. It is mainly due to the tenacity of one member of this group, Miguel Costa that the whole expedition wasn't bogged down. He invested every bit of spare time in preparing for the trip and wouldn't hear of quitting even when all the odds were against the success of the project. Finally the entire group left for China in October of 2003. They started out together in Shanghai and after that they split up in 3 groups of 2 students to go to 3 different provinces (Shandong, Jiangsu and Yunnan). At the end of the trip they all joined again in the Beijing area and finished their data gathering. It was due to their Chinese partners that they were able to visit every possible location that could give them the information they needed. Also the combination of visits to foreign companies and joint ventures and Chinese companies and institutes gave a broad and detailed view of the horticultural situation.

After the group returned their minds were full of impressions, yet they immediately proceed with the task of analyzing the data and creating a well funded SWOT analyses of every municipality/province they had visited. It is especially the combination of technical knowledge with marketing and logistic information that makes this analysis up-to-date, innovative and unique. I am very proud of these students and post-docs, for they have created a piece of work of very high value to the Horticultural sector. And they have done it on a shoe-string budget and with a lot of support of both the Dutch horticultural industry and of the Chinese scientific community. They are an example of the traits that made Dutch horticulture successful in the last century, i.e. tenacity, co-operation, efficiency, innovation and a strong urge to do things really right at the first try.

I wish you a lot of informative joy reading this report.

Prof. Dr. Olaf van Kooten
Horticultural Production Chains group
Wageningen University
February 10, 2004

Acknowledgements

This report is the result of a project initiated by the Horticultural Production Chains group of Wageningen University, The Netherlands and supported by several Chinese research institutions as well as private companies from the Dutch and international greenhouse sector. Information was collected via literature study and a 3-week study tour to China.

We wish to thank Dr. Ximing Hu, Dr. Martin Beek, Dr. Wang (Shandong Pomology Institute), Dr. Xuehao Chen (Yangzhou University), Mr. Shengen Xiao (Shaanxi University), Rami Alsouqui (Royal Brinkman) and Dr. Qingliang Niu (Shanghai Jiaotong University) for their advice and suggestions when preparing the program for the study tour. Mr. Xiao Shengen is also thanked for all the support given in the translation and contacts with our partners in China. Our thanks also go to Prof. Hugo Challa (Horticultural Production Chains Group and Farm Technology Group, Wageningen University) (deceased) for providing us with a preliminary list of Chinese contacts, and for his advice and kind support given during the initial phases of the project.

We extend our deep regards to all Chinese partners and to their Universities or Institutes for all their diligence, interest, logistical and financial support during the visit to China. We thank especially the following contact persons in the different provinces: Dr. Wang and Mr. Anning (Shandong Pomology Institute), Dr. Qingliang Niu and Prof. Danfeng Huang (Shanghai Jiaotong University), Dr. Xuehao Chen (Yangzhou University, Jiangsu), Prof. Luo Weihong (Nanjing Agricultural University, Jiangsu), Mr. Lambricks and Mrs. Yang Yang (NBSO-Kunming, Yunnan), Prof. Yu Yang (Yunnan Agricultural University, Kunming) and Prof. Qu Donggy and Prof. Sun Zhong-fu (Chinese Academy of Agricultural Sciences, Beijing).

We address also our thanks to Mr. Wim Weerdenburg for receiving and showing us the Sino-Dutch Horticultural Training and Demonstration Center (SIDHOC) (Pudong, Shanghai) and Mr. Pieter Gooren and Rubert Konijn (Royal Dutch Embassy, Beijing), for receiving us and discussing several matters regarding the situation and prospects of greenhouse horticulture in China.

We are grateful to the financial partners in this project and their representatives Prof. Martin Kropff, Plant Science Department of the Wageningen University (the Netherlands), Mr. Dennis van Dijk, De Ruiter Seeds (The Netherlands), Mr. Johannes Bosch and Mr. Kelvin Tan, Klasmann-Deilmann (Germany), Mr. Henk Ten Brinke Practical Training Center PTC+ (The Netherlands), Mr.Derko den Otter, Saint-Gobain Cultilène B.V. (The Netherlands) and Mr. M. Wubben, Rijk Zwaan (The Netherlands). Without them this project would be impossible! Thank you for believing in our work and showing interest until the end!

Thanks also to Helen Amstrong (Reedbusiness International) for the nice co-operation in publishing about our project in the last year and for the English corrections in some of the chapters and to Dziedzia Ruibing (Horticultural Production Chains Group) for her help in correcting the small details of the reports.

Finally, our thanks go to Prof. Olaf van Kooten, head of the Horticultural Production Chains group, for embracing this initiative and providing the necessary office facilities for this project.

Dr. Miguel Costa (project-leader and trip organiser)

On behalf of the visiting group:
Niek Botden MSc., Dr. Susana Carvalho,
Dr. Oliver Körner, Dr. Miguel Costa,
Dr. Ep Heuvelink, Anke van der Ploeg MSc.

List of abbreviations

AAHS - Annual accumulated heat sum
BAAS - Beijing Academy of Agricultural Sciences
CAS - Chinese Academy of Science
CAAS - Chinese Academy of Agricultural Sciences
CABTS - China Agricultural Broadcast and Television Schooll
CAU - China Agricultural University
CCIDED - China Counsil for International Cooperation on Environment and Development
EVA - Ethyl Vinyl Acetate
EU - European Union
FAO/UN - Food and Agriculture Organization of the United Nations
FDI - Foreign Direct Investment
GATT - General Agreement on Tariffs and Trade
GDP - Growth domestic product
GMOs - Genetically modified organisms
GTZ - German Agency for Technical Co-operation
HRS - Household Responsibility System
ICEX - Instituto Español de Comercio Exterior
IPM - Integrated Pest Management
IPPC - Irish Peat Land Conservation Counsil
IPR - Intellectual Property Rights
ISHS - International Society of Horticultural Science
IVF - Institute of Vegetable and Flowers
IMF - International Monetary Fund
FIEs-Foreign Invested Enterprises .
LNV- The Dutch Ministry of Agriculture, Nature and Food Quality
NATESC- China National Agro-Tech Extension and Service Center
NAU - Nanjing Agricultural University
NBSO - Netherlands Business Support Office
OFDC- Chinese Green Food Development center
OECD - Organisation for Economic Co-operation and Development
PANNA - Pesticide Action Network North America
PE - polyethylene
PVC - polyvinylchloride
PPI- Potash & Phosphate Institute
SAAS[1] - Shanghai Academy of Agricultural Sciences
SAAS[2] - Shandong Academy of Agricultural Sciences
SAU - Shandong Agricultural University
SIDHOC - Sino Dutch Horticultural Demonstration Training Center
SJAU- Shanghai JiaoTong University
SPI - Sociedade Portuguesa de Inovação
UNIDO - United Nations Industrial Development
UPOV - International Union for the Protection of New Varieties of Plants
WUR - Wageningen University and Research Centre
WTO - World trade organization
YAU - Yunnan Agricultural University
YFA - Yunnan Flower

Summary

The role of China in the world-wide horticultural sector changed considerably in the last decades. China is at present the world's largest producer of fruits and vegetables with 350-400 million tons in 2001-2002 and has also become the world's largest producer of ornamentals. China is the country with the largest area of protected cultivation, which is estimated at 2 million ha. This area is mainly located in the north and is almost fully occupied by vegetables. Plastic tunnels and solar (lean-to) greenhouses are the most important greenhouse structures. Modern plastic multispan or Venlo-type glasshouses occupy a minor area (400-700 ha) and are only used at demonstration centers, research institutes or large private or state-owned companies. Chinese greenhouse horticulture expanded fast since the 80's but it also faces several constraints, which can limit its further development. A small-scale and scattered production structure makes it difficult to organise the sector and enforce the law (e.g. breeder's rights). On the other hand, it has guaranteed employment and social stability in rural China. Land and water are scarce in China. The per capita availability of water is about 1/4 of world's average and the per capita tillable land is about 1/3. Moreover, water use efficiency is low (furrow irrigation is commonly used in open field or greenhouse) and problems with water and soil pollution exist. Logistics, transport and storage structures need investment and modernisation, although the progress in road and railway infrastructures has been remarkable in some regions. The greenhouse manufacturing industry has made a lot of progress and is now able to offer high tech greenhouses at competitive prices. The Chinese seed market is the second largest on a global scale (about € 2,440 million) and has still potential to grow. The new Seed Law approved in 2000 helped to re-organise the sector and facilitated the activities of foreign seed companies. However, the government still controls the seed industry. Breeder's rights are not totally guaranteed but the situation is improving. Vegetables are commercialised via free and wholesale markets (both indoor and outdoor) and more recently by supermarkets and hypermarkets. Pot plants and cut flowers and cut foliage are sold via free and wholesale markets and florists. The auction system is also being used (e.g. in Yunnan and Beijing for cut flowers). Like production, commerce lacks specialisation as a way to decrease the risk and satisfy the customers.

Beijing and Shanghai municipalities are two of the most populated and rich urban areas of China. As consequence they represent two of the most important consumption centres of vegetables and ornamentals in China. Both municipalities preserve a typical peri-urban horticultural activity either in open field or greenhouses. Shanghai has about 2,700 ha of protected cultivation area whereas Beijing has about 5 times larger area due to the cold winters. In both municipalities vegetables are the most important greenhouse crops. Production of cut flowers and pot plant (cyclamen, bromelia, poinsettia) is also becoming more relevant. Propagation in vitro of phalaenopsis is also a relevant activity in both municipalities. Shandong and Jiangsu are two of the five largest vegetable-producing provinces. Shandong has the largest cultivated area of vegetables of whole China (1.8 million ha) and also the largest greenhouse area (400,000 ha), which is half tunnels and half solar greenhouses. Cucumber and tomato are the most important crops. Fruit trees and ornamentals (e.g. garden plants and bonsai) are also important in Shandong. The province has

one of the 10 largest wholesale vegetable markets of China in the city of Shouguang which has emerged as a competitive horticultural area in east China. Shandong is also producing and exporting processing vegetables (e.g. asparagus) and organic products. Jiangsu province is the most important province regarding ornamental production especially that of ornamental trees. Cut flowers and pot plants are mainly produced in the southern provinces of Yunnan (about 50% of China's cut flower production) and Guandong (largest area of foliage and flowering pot plants). The ornamental production in Yunnan occupies about 6,250 ha of which 60% is used for cut flower/foliage production. Carnation and rose but also lily, gerbera, limonium, gypsophyla, statice and gladiolus are produced. Large-scale companies, both governmental and private, are increasing mostly with the aim to export. Yunnan has at present limited export possibilities as it is far from the main consumer centres, refrigerated transport is hardly available and no direct flights to the main export markets exist.

Regarding the future, Shanghai and Beijing are expected to remain as major markets for vegetables and ornamentals (e.g. cut flowers, garden plants) coming from other provinces (e.g. Shandong, Jiangsu, Yunnan) where they can be produced cheaper. Greenhouse pot plant production is expected to be a competitive activity in those two municipalities due to the proximity of a high market segment, the availability of know-how and research and the good quality of the product. This could compensate an increase in the labour and land prices in both cities. The future of Shandong province will emphasise on the optimisation of the greenhouse vegetable production and the improvement of yields and quality by using more imported seeds. Regarding Jiangsu, the province will keep playing a leading role in the production of ornamental trees and shrubs and also keep an important position in vegetable production. It is quite possible that exports of processing vegetables will increase for both Jiangsu and Shandong provinces. Yunnan is expected to lead cut-flower production and the propagation material production. The competitiveness of the Chinese greenhouse horticulture as a whole and regarding vegetables and possibly pot plants or cut foliage will likely relay on the low price with an acceptable to high quality product and will compete mostly with other Asian countries. It is expected that China will increase exports in the coming years but the bulk of the Chinese horticulture produce will be sold in the domestic market. In this sense, China could be considered as a huge "closed and internal" market that requires mainly high quality starting material, know-how and innovative technology from abroad.

Chinese Summary

总　结

过去十年，中国在世界园艺界所扮演的角色发生了显著的变化。目前，中国是世界上最大的水果和蔬菜生产国。2001—2002 年的水果和蔬菜产量达到 3 亿 5 千万至 4 亿吨。中国已成为世界上最大的花卉植物生产国。中国的保护地栽培面估计达二百万公顷，为世界第一，主要在北方，几乎都种蔬菜。塑料大棚和太阳能温室是最重要的温室结构。现代化的塑料温室或玻璃温室只占一小部分（400- 700 公顷），而且仅用于示范中心，研究机构，或者大型的私有公司和国营企业。自 80 年代以来，中国的温室园艺迅速扩展。但也面临诸多的限制因素而可能影响其进一步的发展。小规模的零星的生产结构使该行业难以组织管理并实行有效的执法（如育种者权利保护）。另一方面，它也保证了中国农村的就业和稳定。中国的土地资源和水资源不足。人均水资源和可耕地面积分别约为世界平均值的四分之一和三分之一。而且水利用率低（露地和温室普遍采用沟灌），存在水土污染问题。尽管有些地区的公路和铁路等基础设施有了显著进步，但后勤，运输和贮藏设施需要资金投入和现代化。温室制造业取得了很大进步。现在已能以具竞争力的价格提供高技术的温室。中国的种子市场规模为世界第二（约 24 亿 4 千万欧元），而且仍有增长的潜力。

2000 年通过的种子法促进了行业重组和外国种子公司的商业活动。不过，种子业仍为政府所控制。育种者权利没有得充分保障，不过情况正在改善。蔬菜的商业销售渠道是自由批发市场（露天和室内）。最近则通过超市或大卖场销售。盆栽植物和切花（叶）是通过自由批发市场和花店销售。拍卖系统也被采用（如云南和北京的切花）。和生产一样，销售也没有以专业化来降低风险并且满足顾客的需求。

北京和上海是中国二大人口最为密集而且富裕的城市地区。因此，它们也代表了中国的二大最为重要的蔬菜和花卉消费中心。二市勾还保留典型的环绕城市的露地和温室园艺。上海的保护地栽培面积约为 2700 公顷。由于北方冬天寒冷，北京的保护地栽培面积是上海的 5 倍之多。蔬菜是二市最为重要的温室作物。切花和盆栽植物（仙客来，凤梨，一品红）的生产正变得与人们的生活日益相关。二市都有以组织培养方式繁殖的蝴蝶兰。山东和江苏是五个蔬菜生产大省中的两个。山东拥有中国最大的蔬菜栽培面积（180 万公顷）。同时也有最大的温室面积（40 万公顷）。其中，一半是大棚，另一半为太阳能温室。黄瓜和蕃茄是最重要的作物。山东的果树和绿化用作物（如庭院植物，盆景）也很重要。该省的寿光市是中国十大蔬菜批发市场之一，成为中国东部有竞争力的园艺生产地区。山东也生产和出口加工蔬菜（如芦笋）和其他无公害产品。江苏则是园林花卉作物（尤其是绿化用树）生产最重要的省份。切花和盆栽植物生产主要在南部的云南省（约占中国切花产量的 50%）和广东省（最大的观叶和观花盆栽植物产地）。云南的花卉生产用地高达 6250 公顷。其中 60% 用于切花（叶）的生产。产品有康乃馨，玫瑰。也有百合，非洲菊，补血草，满天星，匙叶草，唐菖蒲。以出口为主要目的的政府和私营的大型企业亦在增长。由于远离消费中心，云南出口产品的机会目前还有限。几乎没有冷藏运输。也没有直达出口市场的空运航线。

未来，上海和北京预计仍将是产自其它生产成本较低省份（如山东，江苏，云南）的蔬菜和花卉（如切花和庭院植物）的主要市场。由于毗邻高端市场，加上有生产技能和科研的依托以及优良的产品品质，两市的温室盆栽植物生产将会有竞争力。这可以弥补两市的土地和劳动力价格的上涨。在今后，山东省将强调温室蔬菜生产的优化，并增加使用进口种子以改进产量和品质。江苏仍将在绿化用树木和灌木的生产上扮演主要角色。在蔬菜生产方面也继续保持在一个重要的位置上。江苏和山东的加工蔬菜出口将很可能增加。云南预计将继续保持其在切花和繁殖材料生产上的龙头地位。就整体而言，中国的温室园艺（主要指蔬菜，也许还有盆栽植物和切枝叶）的竞争力将依赖较低的价格和可接受的至较高的品质。并主要与亚洲国家竞争。预计在未来几年，中国将会增加出口，但大部分产品将用于内销。在这个意义上，可以把中国看成是一个巨大的封闭的内部市场，它需要的主要是来自国外的高品质的初始材料，生产技能和先进技术。

Table of contents

1.
Introduction

by J. Miguel Costa and Ep Heuvelink

1.1 Protected cultivation world wide

Horticulture is an intensive form of agricultural production regarding the use of labour and capital. This is specially the case for the protected cultivation of vegetables and ornamentals (cut-flowers, ornamental pot plants). It has developed as a result of technological advancement and the rise in demand for more expensive, out-of-season and exotic products related to the increasing prosperity of a growing group of citizens (Bakker and Challa, 1995). At present cultivation in greenhouses (protected cultivation) may be considered the most intensive and advanced form of crop production. In fact, it has been frequently described as the "greenhouse industry", which emphasises the important role of technology in the whole process (Bakker and Challa, 1995).

Compared to open field cultivation greenhouse horticulture offers the possibility of year-round production, higher yields by better control of pathologies and climate and higher water use efficiency (Stanghellini et al., 2003). However, and in spite of the high economy/resource use efficiency, production in greenhouses is an intensive production system which has a significant environmental impact that needs still to be investigated and minimised (Stanghellini et al. 2003).

Protected cultivation ranges from row covers (small tunnels) to unheated and heated greenhouses, and is mainly concentrated in the temperate latitudes (Hurd and Sheard, 1981). In 1999, the world's total protected cultivation area (small and large plastic tunnels and glasshouses) was estimated to be 1.6 million ha with about 700,000 ha occupied by greenhouses and large plastic tunnels and 900,000 ha occupied by low tunnels (Jouët, 2001).

The geographic distribution of protected cultivation shows different patterns for cultivation under plastic or under glass. Asia has the largest concentration of plastic greenhouses in the world (Table 1). The second largest concentration of plastic greenhouses is located in the Mediterranean Basin which includes several South European countries (e.g. Spain, France, Italy, Portugal, Greece) and countries from North Africa (e.g. Morocco, Egypt) and the Middle East (Israel, Turkey) (Pérez et al., 2002). On the American continent, plastic greenhouses are mainly found in Latin American countries and in the Southern parts of USA.

World wide, the total area of glasshouses has been estimated at 40,000 ha (Jensen, 2001). The largest area is located in Europe, in particular in the Netherlands (10,500 ha) but also other countries like Italy, Spain or France possess considerable areas (Table 1). On the American continent glasshouses are located mainly in USA and Canada (Jouët, 2001). The area of glasshouses in Asia is small, but countries like Japan and South Korea possess a considerable area and in countries like China the glasshouse area is increasing (only 320 ha in 1999) (Zhang, 1999).

1.2 Study Background

World-wide, greenhouse vegetable production is dominated by several countries from Europe (Spain and The Netherlands) and from America (Mexico, Canada and United States) (British Colombia Ministry of Agriculture, 2003). Production of ornamentals (flowers and pot plants) in greenhouses is dominated by some countries of Asia and Pacific (Japan, South Korea and Thailand), America (Brazil, Colombia, USA and Canada), Africa (e.g. Kenia), and Europe (Spain, The Netherlands, Italy) (AIPH, 2003).

However, the relevance of China in the context of world-wide horticulture increased dramatically in the last decades in terms of production and protected cultivation area. According to FAO, between 1970 and 2002 there was a 700% raise in the production of fruits and vegetables and China has become the world's largest producer with about 370 million tons in 2002 (Cody and Blenkinsopp, 2003; Costa et al., 2003). Ornamental horticulture (cut flowers, pot plants and garden plants) experienced also fast development in the last decade (Dutch Horticultural Board-LNV, 2002) and China is at the moment one of the largest producers of flowers and pot plants world wide. The fast increase in vegetable and ornamental production occurred in parallel with the fast expansion of the protected cultivation area which increased from about 10,000 ha in beginning of the 80's (Jiang et al., 2004) to about 1.7-2.0 million ha (small tunnels included) more recently (Zheng, 2003; Zhou et al, 2003). These fast developments in the Chinese greenhouse sector got attention from the world wide horticultural players not only from those ones searching for business possibilities but also because these developments may represent a threat to them, in particular, as China became a member of the WTO.

Table 1.1: Total protected cultivated area (greenhouses and large and small tunnels and glasshouses) in the main horticultural countries (Adapted from Jouët (2001). Data from Jouët is relative to 1999. Other references are more recent (2000-2003).

	Area (ha)		
Location	**Greenhouses and large tunnels (plastic)**	**Small tunnels (plastic)**	**Glasshouses**
Europe			
Total	**160,000**	**90,000**	-
Italy	61,900	19,000	5,800
Spain	46,852[f]	17,000	4,600
France	9,200	20,000	2,300
The Netherlands	400	-	10,500[a]
UK	2,500	1,400	1,860
Greece	3,000	4,500	2,000
Portugal	1,177[d]	450	-
Ex-Yugoslavia	5,040	-	-
Poland	2,031[i]	-	1,662[i]
Hungary	6,500	2,500	200
Africa and Middle East			
Total	**55,000**	**112,000**	-
Egypt	20,120[c]	17,600[c]	-
Turkey	17,510[c]	26,780[c]	4,682[e]
Morocco	10,000[d]	1,500[d]	500[d]
Israel	5,200	15,000	1,500
Asia			
Total	**450,000**	**653,600**	-
China	380,000	600,000	-
South Korea	43,900[h]		-
Japan	51,042	53,600	2,476
America			
Total	**22,350**	**30,000**	-
USA	9,250	15,000	1,000
Canada	600	-	350
Colombia	4,500	-	
Mexico	2,023[g]	4,200	
Equator	2,700		
WORLD TOTAL	**687,350**	**885,600**	

Sources: Jouët 2001; a) CBS (2003); b) Costa and Monteiro (2003); c) La Malfa (2003); d) New AgInt, 2003; e) Öztürk et al., 2001; f) Perez et al., (2002); g) Cantliffe and Vansickle, 2003); h) Park and Lee (2001); i) Knaflewski (2003).

1.3 Aim and methodology of the study

The aim of this book and the project behind it ("Greenhouse horticulture in China: situation and prospects") is to describe and analyse the current status and future trends of the Chinese greenhouse horticulture using five major greenhouse horticultural provinces/municipalities as basis for the study. Three of them are typical producer centers of greenhouse vegetables (Jiangsu and Shandong) or of cut flowers (Yunnan). The other two, Beijing and Shanghai, are typical modern and large

consumer centers of vegetables, fruits and ornamentals and also maintain a relevant peri-urban greenhouse horticulture. Moreover, these regions, with the exception of Yunnan, are located in the richest part of China, where the greenhouse horticultural sector is developing fast.

The study aims at compiling and analysing information regarding protected cultivation of vegetables and ornamentals (cut flowers, pot plants, nursery-stock) and related aspects (e.g. greenhouse structures, substrates, environment, the seed industry and research and education) for the five above mentioned regions. It should help in identifying constrains and opportunities for the sector in terms of business, training and research opportunities.

The study comprised three phases. The first included an extensive literature review and writing of a preliminary report entitled "Greenhouse horticulture in China: situation and prospects" (by J.M. Costa) and the elaboration of a MSc Thesis entitled "Market trends and scenarios for the ornamental markets of emerging China" (by P. Keijzer). The second phase of the project consisted in a 3-week study visit to the above mentioned provinces/municipalities (see program in Appendix) with a team of six researchers from Horticultural Production Chains group, Wageningen University, The Netherlands. The visit was organised in co-operation with several Chinese Universities, Institutes and Dutch diplomatic representations in China (e.g. NBSO) and received financial support from several private partners from the greenhouse sector. The third and ultimate phase of the project consisted in the writing, editing and publishing of the present report where previous literature information is combined with data, impressions and experiences collected during the visit.

1.4 Report structure

The report gives in Chapter 2 a description of the most relevant historic and political aspects which have influenced the greenhouse horticultural sector in China. It provides up-to-date information on cultivated area of vegetables and ornamentals, type of greenhouse structures and equipment in use, substrates, environment, seed industry, market and supply chain and research and education. It incorporates literature and already some data collected during the visit. Chapters 3 to 7 are detailed descriptions of the greenhouse horticulture sector in each of the 5 visited regions: Beijing, Shanghai, Jiangsu, Shandong and Yunnan. The specific aspects of each of the provinces/municipalities (e.g. climate, vegetable and ornamental production, production methods, starting material, substrates, marketing, commerce and research) are described in those chapters.

Chapter 8 provides a SWOT analysis for each of the five provinces. Strengths and Weaknesses, Opportunities and Threats for the greenhouse horticultural sector in each of the provinces are presented. Major conclusions regarding competitiveness of the sector are discussed.

2.

China's greenhouse horticulture: an overview

by J. Miguel Costa and Ep Heuvelink

Abstract

The role of China in the world wide horticultural sector has changed considerably during the last decades. China has become the world's largest producer of fruits and vegetables with 350-400 million tons (2002) and it is also the largest producer of ornamentals (cut flowers, pot plants, nursery plants). The area of protected cultivation has grown from 10,000 ha in the beginning of the 80's to about 2 million ha (small tunnels included), also the largest in world. Greenhouse horticulture is mainly located in the northern provinces (e.g. Shandong, Jiangsu or Liaoning) and on almost the whole protected cultivation vegetables are grown. The main greenhouse structures are plastic tunnels and solar greenhouses. Modern greenhouse structures occupy only a small area (400-700 ha). Cultivation is mostly done in soil as soilless cultivation (eco-soiless or hydroponics) occupies only 1,020 ha. Shandong, Henan, and Jiangsu were the 3 largest producers of vegetables in 2001. Jiangsu, Yunnan and Guandong are the most relevant provinces in terms of ornamental production. Jiangsu is the largest producer of ornamental trees and Yunnan is responsible for 50-60% of the total cut flower production in China. The greenhouse horticultural sector expanded fast but is still has constraints. For example, the scattered and small-scale production structure makes it difficult to co-ordinate and organise the sector and makes it difficult to provide governmental extension and law enforcement (e.g. breeder's rights). Low water use efficiency and pollution due to the use of agrochemicals are other problems. The government is promoting organic production estimated at about 100,000 ha. The Chinese seed market is the world's second largest (€ 2,440 million) and has still potential to grow. Because of that foreign companies are already present in China but the seed industry remains strongly dominated by the government. In 2000, the new Seed Law represented progress for the sector as it provided the legal basis to go against illegal propagation. It also allowed foreign companies to have easier access to the market. Even so, breeder's rights are not always respected. Regarding research, institutes are undergoing major changes as governmental funding is decreasing and they are being partly privatised. The universities are probably the most international sector in China due to the active exchange of students and teachers with abroad. Research is rather focused on yield optimisation (e.g. via biotech means, use of high tech greenhouse technology) but the sustainable use of natural resources (e.g. biodiversity, water and soil) is receiving increasing attention.

2.1 Brief characterisation of the country

China is located in Central and East Asia. It makes borders with Mongolia, Russia and Kazakhstan to the north, North Korea, the Yellow Sea and the East China Sea to the east, the South China Sea, the Gulf of Tonkin, Vietnam, Laos, Myanmar, India, Bhutan and Nepal to the south as well as India, Afghanistan, Pakistan, Tajikistan and Kyrgyzstan to the west.

China has an area of about 9.6 million km^2 and a total population of 1.3 billion inhabitants. More than 66% of its territory is hill, mountain and high plateaux. The multiplicity of agricultural systems one can find in China is a direct consequence of multiple climate specificities in different regions (Table 2.1 and Fig. 2.1).

Table 2.1: The eight major agricultural climate zones of China according to Wittwer (1987).

Cold Plateau	Tibetian Plateau of Southwest China. Sixty percent of the area 4,500m above the sea level with. Average temperature in the warmest month < 10°C; No absolute frost-free period
Cold temperate	Small area in the northernmost part of Heilongjiang; AAHS < 1,600°C; Frost free period < 100 days.
Temperate	Northeast provinces (Heilongjiang, Jilin, Liaoning) and most of the northern parts of North China; AAHS=1,600-3,400°C; Frost-free period: 100-160 days
Warm temperate	Extends from the southern end of the medium temperate belt to the Qin Ling Mountains and the Huai He River. AAHS = 3,400-4,500°C; Frost-free period: 160-190 days
North subtropical	AAHS = 4,500-5,000°C; Frost-free period: 210-250 days
Middle subtropical	AAHS = 5,000-6,500°C; Frost-free period: 250-300 days
South subtropical	AAHS = 6,500-8,000°C; Frost-free period >300 days;
Tropical belt	Leizhou Peninsula, Hainan Island, the border areas of Yunnan and the southern third of Taiwan.

AAHS: Annual accumulated heat sum > 10^0C

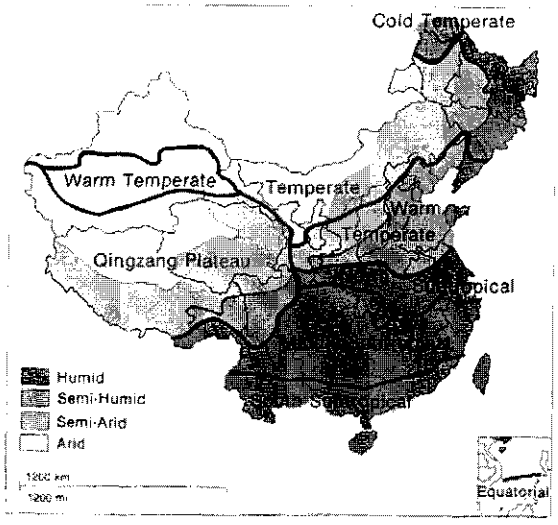

Fig. 2.1: The eight major agricultural climate zones in mainland China defined by Wittwer (1987).

Beijing is the sovereign administrative seat for the People's Republic of China and rules a total of **32 territorial districts** (Fig. 2.2). Of these, **23 are provinces** (Anhui, Fujian, Gansu, Guangdong, Guizhou, Hainan, Hebei, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Jilin, Liaoning, Qinghai, Shaanxi, Shandong, Shanxi, Sichuan, Yunnan, Zhejiang, and Taiwan), **5 are autonomous regions** (Guangxi, Nei Mongol, Ningxia, Xinjiang, and Xizang (Tibet) and **4 are municipalities** (Beijing, Chongqing, Shanghai, and Tianjin) which have their own local government.

After the death of leader Mao in 1976, China experienced a gradual easing of the political system and the decentralisation of the economy. The adoption of reforms since 1973 (see Table 2) boosted China's economy. Since then, it has quadrupled its size and now its GDP is the 6th largest in the world. Recent official estimates from 2002 indicated a growth rate of 8% and although many independent economists believe this is an exaggerated figure, few doubt that China's economy is booming (The Economist, 2003). Although reforms (Table 2.2) were very positive for the economy, the political and economical decision-making remains strongly driven by the central government. High levels of public bureaucracy limit the opportunities for foreign investors (SPI, 2002) and the development of a globally competitive Chinese private sector (Huang and Khanna, 2003).

Moreover, the economic growth was not able to fully overcome poverty and unemployment (SPI, 2002; Huang and Khanna, 2003). Another critical issue is the contradiction between the market economic system and the political system which can facilitate the development of mal management practices.

Table 2.2: Main reform steps in China from 1973 to today.

Year	Reform steps
1973	Announcement of the Four Modernisation
1978	Deng Xiaoping establishes the Open Door Policy
1980	China becomes IMF member
1983	Patent law enacted
1986	China applies to join GATT
1992	Patent law revision: China joins World Intellectual Property Organisation
1994	IPR court established
1997	Announcement of the restructuring of the state enterprise sector including some privatisation
2000	Conclusion of bilateral market access agreement with the EU (most commitments to be implemented by 2005)
2001	China becomes WTO member

Adapted from SPI - Sociedade Portuguesa de Inovação (2002)

Fig. 2.2: Provinces, municipalities and autonomous regions of China. Source: http://www.chinaoninternet.com /area/areaindex.htm

The Agricultural Sector

China is recognised as feeding 22% of the world population with only 7% of the world's farmland (Weimin, 2001). The Chinese agricultural sector experienced big changes in the last century. Prior to the 1949 Revolution and establishment of the People's Republic of China growers were farm house holders who owned their own land or rented it from landlords. After 1949 agriculture become fully planned and by 1958 most farmers were organised into communes (economic collectives). The communes prevailed until 1984 when a new rural management system based on the *Household Responsibility System* (HRS) was adopted (Shields and Tuan, 2001; Weimin, 2001). Since then the

rural economy of China has been based on small family farms cultivating narrow strips of land. This could be considered an inefficient organizational set up but was essential to maintain employment and stability in the rural areas (Chang, 2002).

Chinese authorities face now the problem of a decrease in the rural income and a large gap between rural and urban incomes (OECD, 2002). The rural income is less than 30% of the urban income and according to OECD experts, this is largely due to economy-wide policies, which put agriculture and rural areas at a disadvantage. The governmental priorities for agriculture shifted from the strict aim of production maximisation to the improvement of product quality in order to exploit China's competitiveness in world's markets (OECD, 2002). Joining the World Trade Organisation (WTO) in 2001 was another determining step for the Chinese agricultural sector because it not only meant new markets but also new pricing and trading rules (OECD, 2002). Nevertheless, the Chinese fruit and vegetable industries seems to be also within the group of competitive industries (OECD, 2002).

2.2 Greenhouse horticulture profile

2.2.1 Vegetables

Production of vegetables in China increased about 700% in the last 3 decades. In 2001, the total production area (including melons) was estimated at 19 million ha with a total output of about 350 to 400 million ton (Qu, 2002; FAO, 2003).

This dramatic increase in production was in part attributed to the economical reform and the conversion of crop land into horticultural land (about 1.2 million ha between 1988-95). The use of hybrid seeds, better production facilities and the establishment of a vegetable seed industry also contributed towards the process (Agrifood-Canada, 2002; Qu, 2002). Important historical political changes also contributed positively to the expansion of the vegetable sector (Ma et al., 2000) namely the change from planned vegetable production to the family responsibility (partially controlled) system (1978-1984) and the change from partially controlled pricing to market pricing (since 1984).

China has rich vegetable germaplasm resources and thus an enormous diversity of vegetables. Some of the most important are: Chinese cabbage, cucumber, tomato, cauliflower , glossy cabbage, purple cabbage, broccoli, eggplant, celery, potato, mini tomato, peppers, peas, lettuce, melons, mushrooms, chicory, brussels sprouts, asparagus, onions and mini radish (Feng, 2001; Jiang et al., 2004).

Greenhouse production of vegetables emerged as an industry in the early 90's. In 1995, the protected cultivated area of vegetables was estimated at 400,000 ha (Diankui and Mingchi, 1998) predominantly in small and large plastic tunnels and in the solar greenhouse. In 2000, the total area was estimated in about 1.4 million ha (Zhang, 2002). More more recent data for 2001 point to an area varying between 1.7 and 2.1 million ha (Zeng, 2003; Zhou et al., 2003; Sun Zhong-Fu, pers.

comm.). In domestic terms, this corresponds to about 10% of the total area producing vegetables and to 20% of the consumed vegetables in China (Zeng, 2003).

Protected cultivation of vegetables expanded fast because yields are higher than in open-field cultivation and it permits production during the winter when market prices of vegetables are higher. Moreover, returns are larger than grain production.

Production structure and consumption

About 90% of vegetable production is based on farms operated by individual farmers who rent land (0.1-0.2 ha) from the local government (Diankui and Mingchi, 1998). This results in a highly fragmented and small scale production structure which limits productivity, efficiency and proper management.

In 2001, the five most important vegetable producing provinces were Shandong (1.8 million ha), Henan (1.4 million ha) and Jiangsu (1.23 million ha) and Guangdong and Hubei with about 1 million ha each (Mello, 2003).

The Chinese diet is very rich in vegetables and the per capita consumption of vegetables is clearly above world's average. Different types of cabbage, cucumber, tomato, radish, peppers, celery, spinach, pak choi and kidney bean are among the most consumed vegetables (Diankui and Mingchi, 1998). Progress and higher living standards modified consumption patterns and as a result new species like asparagus, broccoli, American lettuce and common endive are being cultivated and consumed (Songlin, 1997). In Shanghai for example, Western vegetable crops have been introduced to satisfy the increasing needs of hotels and restaurants and of export markets.

2.2.2 Ornamentals (cut-flowers, pot plants, nursery stock, and foliage)

China's ornamental industry developed fast in the last two decades. In 2000, the area of ornamentals (cut flowers, pot plants, ornamental trees, young plants, bulbs and seeds) was almost 150,000 ha (Table 2.3) with a total output of almost 1.62 billion Euros (Dutch Horticultural Board-LNV, 2002). Non-official figures point towards a much larger producing area in 2002 and that should be around 300,000 ha.

Cut flowers and cut foliage

China's cut flower industry started in 1984 (Jiang et al., 2004). By the end of 2001, China had more than 20,000 flower growing enterprises and over 2,000 flower wholesale markets, with about 1.45 million people working in the sector (Anonymous, 2002a). In 2000, rose, chrysanthemum, carnation and gladiolus were the main cut flower crops (63% of the total production) but crops like gerbera, lily, antirrhinum, cymbidium or anthurium are also grown (Wernett, 2000; Bent, 2000).

The major greenhouse cut flower species are rose, gerbera, lily, anthurium and limonium. The production area of rose is estimated in 2,450 ha and is almost exclusively done in greenhouses (Jiang et al., 2004). The Yunnan province is the largest cut flower producing region and accounts for about 50% of the country's total production (NBSO, 2003). Guangdong and Sichuan are the second and third most important cut flower producing areas (Dutch Horticultural Board-LNV, 2002) (See (Appendix 1). Guangdong and Fujian provinces, due to their warm and humid climate are the most important production bases for cut foliage but also Hainan and Yunnan increased their production in recent years (Wernett, 2000).

Cut flower production has the same production structure as vegetables and is mainly done by small farmers cropping tiny strips of land of 1-2 mu (1mu = 666 m^2), often organised into collectives, alternating flowers with vegetables according to season. Flower quality is generally very heterogeneous because of simple production facilities, bad quality of starting material and a deficient extension service. Besides the domestic market is in general not yet sensitive to flower quality. This means that low quality production keeps expanding.

Flower consumption is mainly a gift market (Keijzer, 2003). Flowers are used during the holidays period (e.g. Chinese New Year), weddings (bride bouquet, cars), new births, birthdays, funerals but also to decorate entrances of new restaurants, banks, shops or hotels (Bent, 1998; Wernett, 2000).

Table 2.3: Total and protected cultivated area destined to each ornamental sector in China in 2000.

Sector	Total (ha)[a]	In greenhouse (ha)[b]
Cut flowers (cut flowers, cut leaves)	10,750	4,000
Pot plants (flowering pot plants, foliage pot plants, bonsai)	18,841	6,800
Ornamental trees (plants for landscape and outdoors)	65,588	-
Medicinal flowers	14,801	-
Industrial flowers	29,479	-
Grass	11,120	-
Flower seeds	1,819	-
Young plants	2,824	-
Flower bulbs	1,281	-

Sources: a) Dutch Horticultural Board-LNV (2002); b) Jiang et al. (2004).

Pot Plants

According to Jiang et al. (2004) production of pot plants developed faster than of flowers. The three most important provinces producing flowering pot plants are Guangdong, Jiangsu and Fujian. Azalea, cyclamen, phalaenopsis, bromelia, poinsettia, begonia, New Guinea Impatience, are the most important flowering pot plants (Wernett, 2000; Dutch Horticultural Board-LNV, 2002; Jiang et al., 2004). Cycas, tropical palms, ficus, pachira, *Epipremnum aureum*, are the major species of foliage pot plants. The main production areas for these ornamental pot plants are Guangdong, Sichuan, Hebei and Jiangsu (Dutch Horticultural Board-LNV, 2002) (Appendix 1).

Nursery stock (ornamental trees, woody plants)

Nursery stock production is probably one of the most promising sectors within the Chinese ornamental horticulture (Liang, 2000; Post and Zhang, 2003). Tree and shrub production represented about 40% of the total production and sales value of the ornamental sector and occupied the largest production area (65,600 ha) in 2000 (Table 2.3). Jiangsu is the province with the largest area dedicated to the production of ornamental trees (Dutch Horticultural Board-LNV, 2000). The combination of governmental afflorestation plans, with expansion of the gardening area makes the nursery sector attractive for Chinese and eventually for foreign investors even though household demand for nursery products remains limited (Post and Zhang, 2003). Woody plants (trees and shrubs) are commonly used in municipal landscaping of streets, public parks, residential areas, highways and railroads (Liang, 2000). According to Bent (2003) the sector has potential to grow and it is possible that Chinese nurseries will not be able to keep up with the demand for certain types and sizes of container-grown nursery plants, ornamental trees and shrubs due to the rapid expansion of the garden area. Moreover, the future organisation of the Olympic Games in 2008 and the World Expo 2010 in Shanghai will also help to advance the sector. However, the number of species available is small in particular in the regions located North of the Yangze river (Post and Zhang, 2003). Lack of professional management and a good link between R&D and the sector are another weaknesses of the sector (Post and Zhang, 2003).

Flower seed production

Yunnan due to its mild climate, high irradiance, and low humidity from October until April emerged also as an important flower seed production centre. Other provinces with good conditions for flower seed production are Inner Mongolia, Shandong and Liaoning (Wernett, 2000).

2.3 The production systems

2.3.1 Land

Rural land belongs to the collective. Village leaders allocate land-use rights among village households based on the family size and labour availability (Post and Weimin, 2002). Land can be normally contracted for a period of 30 years and selling and buying of land is forbidden. Renting is possible with governmental permission (Post and Weimin, 2002).

In Shandong farmers were paying the government € 40-60/mu/year (1 mu = 666m^2). It is expected that land rent will decrease to compensate for the decreased income of the rural areas relatively to urban areas.

2.3.2 Greenhouse structures

Greenhouse horticulture in China has experienced fast growth over the last decades. In the early 1980's the protected cultivated area was less than 10,000 ha and in 1999 the area was about 1.4 million ha (Table 2.4). According to different sources, the are estimated for 2001-2002 should vary between 1.7 and 2.1 million ha (Sun Zhong-Fu pers. comm.; Zheng, 2003; Zhou et al., 2003). This makes it the largest area of protected cultivation in the world!

Vegetable or ornamental production in China is mainly carried out in small scale and cheap greenhouse structures (plastic tunnels or solar greenhouse). The large scale and modern greenhouse operations belong to village-state farms, demonstration centers or private companies. Research institutes and Universities also use modern greenhouse structures.

The solar greenhouse

The Chinese solar greenhouse (also called lean-to or energy-saving greenhouse) originated in the 80s' in the Liaoning Province (Zhang, 1999; Jiang et al., 2004).

Table 2.4: Protected cultivated area in China since 1985 until 1999.

Type of Structure	**Area (x10^3 ha)**						
	1985[a]	1987[a]	1989[a]	1991[a]	1993[a]	1995[a]	1999[b]
Small plastic tunnel	30	69	104	129	186	333	568
Large plastic tunnel	8	17	24	50	80	133	459
Solar greenhouse (non-heated)	4	12	16	26	74	160	352
Solar greenhouse (heated)	2	3	4	5	6	7	15
Multispan greenhouse	-	-	-	-	-	-	-
Glasshouse	-	-	-	-	-	0.06	0.3[a]
TOTAL	**43**	**100**	**148**	**209**	**346**	**634**	**1,400**

Sources: a) Zhang (1999) ; b) Jiang et al. (2004); -) not available by the time of publication

It may be considered as one of the most successful cases of a Chinese made greenhouse structure (Chen et al. 2000) and permitted vegetable cultivation in extremely cold areas (32-41° N or even 43°N) without, or with little use of, heating (Chengwei et al., 1999). In 2001, the area of this type of greenhouse was estimated at 350,000 ha (Jensen, 2001) and the current area is estimated in 500,000 ha (Sun Zhong-Fu and Chen Sheng, pers. comm.). The solar greenhouse is typical from North China, in particular provinces like Shandong or Jiangsu. The main distinguishing characteristic of this type of greenhouse compared to tunnels or glasshouse is that three-sides are non-transparent. The walls (the back and the two side ones) are often built of soil or bricks to preserve the internal temperature (Zhang, 1999; Yuan et al., 2001; Jiang et al., 2004) (Fig. 2.3). In cheaper structures

walls are made of clay soil and the cover supporting structure is made of bamboo. Other structures use wood and wire and the most expensive have a metal or concrete structure. The construction costs of the solar greenhouse vary between € 0.9-3.0/m^2. The flexibility in terms of construction materials and costs is another reason for the popularity of the solar greenhouse in Middle and North China. Polyethylene (PE) film (0.08-0.1 mm thick) and Polyvinylchloride (PVC) are used as covering materials.

Because the energy resources of the greenhouse come exclusively from the sun and only a small part of the greenhouses is heated (Table 2.4), growers use straw mats over the plastic cover to keep the greenhouse warm during the cold nights in the winter. The mats are opened after sunrise and drawn before sunset (Yuan et al., 2001). These mats have a low surface heat conduction coefficient (2 $Wm^{-2o}C^{-1}$) according to Chengwei et al., (1999) which permits them to maintain the inside temperatures around 7-10 °C when the outside temperature can be as low as -10°C! The straw mats have the disadvantage of damaging the plastic cover and they are easily wet by rain or snow which diminishes heat preservation and makes them very heavy (Chengwei et al., 1999). At present there are also synthetic mats with good insulation properties which are less heavy and easier to transport than the straw mats (Jiang et al., 2004).

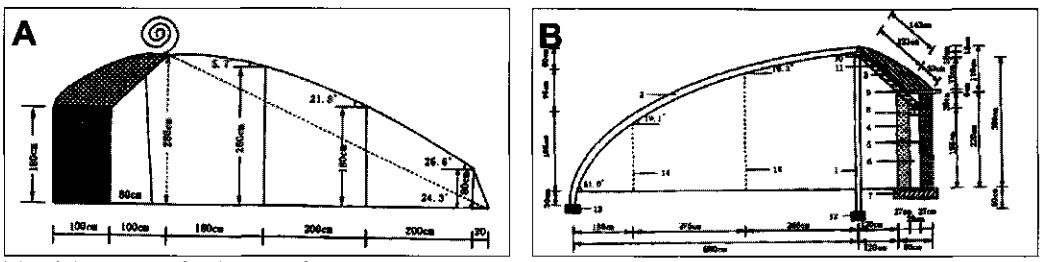

Fig. 2.3: Types of solar greenhouse structures: **(A)** Section sketch map of improved solar greenhouse in Shouguang and **(B)** Section sketch map of Wutai type solar greenhouse in Shouguang (Chen Yunqi 1998): Source: He Qiwei and Lu Yuhua (2002). Systemic technique study and practice of Shandong new type solar greenhouse vegetable. Shandong People Press.

The solar greenhouse is always oriented south or south by east or west within 15° and in general has an area of 150 to 800 m^2 (width: 5 – 10 m, length: 30-80m) which can be easily managed by a 3-5 person family (Yuan et al., 2001). The solar house is ventilated by moving up the plastic sheet where it touches the ground and/or moving it down a little from the top (Sonneveld, 2002). Some constructions also have openings at the North wall that permit ventilation in summer. These openings are closed during winter.

Moreover, when it is heated, the solar greenhouse has a very low consumption of coal and thus causes limited pollution (FAO, 1994).

The solar greenhouse also has disadvantages. One is the little space for mechanisation (Zhang, 1999). Another is the restricted height at the low end (Fig. 2.3) which makes it impossible to grow fruit or vegetables of more than about 1m high and limits the possibility to achieve maximum yields

(Sonneveld, 2002). Another major inconvenience of this structure is that is deprived of a climate control system and ventilation problems often and generally result in excessive relative humidity or low CO_2 concentration in particular when the greenhouse is completely closed (Wei et al., 2002). Low light intensity inside the greenhouse may also be a limiting factor to grow vegetable crops as suggested by Chen et al. (2003) in respect to muskmelon grown in Guangsu province.

Plastic tunnels (small, middle and large)

Plastic tunnels are popular all over the country and started to be largely adopted in the 70s when plastic films started to be produced in China (Chengwei et al., 1999; Zhang, 1999). In the northern parts of China tunnels are used in early Spring and late Autumn (e.g. from March till July and from August till November in Beijing) whereas in the South regions tunnels are used all year (Jiang et al., 2004).

The large plastic tunnel is usually a single structure, 8-12 m wide and 2.5-3.0m ridge height (Zhang, 1999) and is built with hoops of bamboo or, but less frequently, with iron (ICEX, 2002). They are normally North-South oriented and have a length of 50 to 60m and are commonly used to grow out-of-season vegetables or flowers (Zhang, 1999).

Middle size plastic tunnels are 4-6m wide, 1.8-2.5m high and 30m long. The small plastic tunnels are only 1-3 m wide and 0.5-1.5m high and are not suitable for high stem vegetables like cucumber but can be used to grow small size vegetables. In 2001 the are of this type of structure was estimated in 850,000 ha (Shields and Tuan, 2001). The tunnels can be also covered with straw mats when the weather is colder (Zhang, 1999).

Multispan and venlo-type glasshouse

After the establishment of the Open-Door Policy the Chinese government imported a considerable number of modern greenhouses. The importation peaks occurred in the beginning of the 80's and in the second half of the 90's (Chang-Ji, 2003). By 1999, the area of glasshouses in China was 320 ha (Table 2.4). By then the most important supplier was The Netherlands (107 ha), followed by Bulgaria (71 ha), Romania (30 ha), Japan (27 ha) and USA (26.7 ha) (Zhang, 1999). Spain, France, Israel, South Korea are other important suppliers of greenhouse structures, mostly in plastic.

Only demonstration centers or large governmental or private companies willing to produce and export high quality products (e.g. flowers) acquired high structures of glass or polycarbonate multispan greenhouses (Dutch Horticultural Board-LNV, 2002). Mostly due to their high price (Table 2.5) the area of modern greenhouses did not increase much (Table 2.4) and the majority (70%) are located in North China mainly in Beijing, Shandong, Hebei and Liaoning (ICEX, 2002). At present the area of modern greenhouses should vary between 400 and 700 ha (Chang-ji, 2003; Zhou et al., 2003; AgriHolland, 2003).

Failure was also frequent due to the lack of know-how which is necessary to manage the modern greenhouse equipment (Cngreenhouse.com, 2003) or simply because the imported greenhouses were not adequate for the climate conditions where they were installed. As a consequence energy consumption for heating during the winter or cooling during the summer was excessively high which dramatically increased production costs (Cngreenhouse.com, 2003). According to Baoming and Qiang (1999) between 40 to 60% of production costs in a heated greenhouse in China are due to heating and cooling.

In many cases, the acquisition of modern greenhouse facilities could be also interpreted as local governmental achievements and classified as *'Image Projects'* or *'Model Projects'*. The absence of a concrete plan for greenhouse acquisition meant that almost all capital cities and some poor districts, imported modern greenhouses. Many of them, unfortunately were left unused representing a waste of money (Cngreenhouse.com, 2003).

The import of greenhouse structures had however a positive aspect because it gave Chinese manufactures a model on which to build their own projects (basically they are imitations of the imported technology). In fact, Chinese companies are now eager to construct these hi-tech greenhouses themselves and offer them at a lower and competitive price. As a consequence it is estimated that about 75% of the actual "turn-key" projects are Chinese (Diario Vasco, 2002). There are several hundred greenhouse builders all over China, but only 8 to 10 can be considered large companies. The Chinese greenhouse industry is therefore of small dimension and has limited or no R&D capacity (ICEX, 2002). Some of the Chinese manufactures are "side-liners" of governmental institutes. Due to that they are able to use the facilities and personal from the institutes and work simultaneously as a commercial company selling their products or representing foreign products in the Chinese market.

2.3.3 Covering materials (greenhouses and soil)

The production of plastic films in China started in the 60s-70s and permitted the fast expansion of the area of solar greenhouse and tunnels area (Chengwei et al., 1999).

Table 2.5: Estimated construction costs for different types of greenhouse structures.

Greenhouse structure	€/m^2
Large tunnel (galvanised steel)	1.8-2.2[a]
Non erected, (steel and local glass)	22.5-34[b]
Shanghai type	16.8-28[b]
French multispan(double layer covering)	50[a]
Israeli plastic greenhouse	43[b]
Dutch Venlo (equipped with heating, irrigation and other technology	59[b]

a) Chen Zhenggang, pers. comm.
b)Dutch Horticultural Board-LNV (2002).

Table 2.6: Plastic production in some of the most important producing provinces

Province	1000 ton	Ranking
Shandong	171.2	1st
Henan	104.7	2nd
Hebei	73.2	3rd
Shanghai	54.0	4th
Yunnan	31.8	10th
Beijing	18.7	12th
Jiangsu	15.8	15th

Source: Adapted from ICEX (2002).

The annual demand of plastic has been estimated at about 2.2 million tons from which 1.5 million are used in new greenhouses and the remaining 700,000 tons are used to renew old covers (ICEX, 2002). Shandong is the province with the largest plastic production (Table 2.6). In general, the quality of the plastic used in simple greenhouse structures is low as it is without co-extrusion or EVA and has a durability of just one to two years (ICEX, 2002). The quality of the plastic used in modern greenhouses structures is better (high EVA content, has better transmissivity and anti drop properties. This plastic is normally imported (ICEX, 2002).

The polyethylene (PE) and polyvinylchloride (PVC) are the most used plastic for covering. Because PVC has higher insulating capacity than PE it is more often used. In Shandong, the price per kilogram of the PE is € 1 which is slightly cheaper than PVC that costs € 1.1. On average 150 kg foil is needed to cover an average solar greenhouse. Polycarbonate panels have been available in the market since 1997 but due to their high price they are mostly used for greenhouse-end walls or for modern greenhouses in demonstration centers.

Plastic mulching is common in China, either in open-field or inside greenhouses (Fig. 2.4). The total area is estimated in about 14.6 million hectares (Cui, 2003). The demand for this type of plastic is about half million tons (ICEX, 2002).

The glass used in glasshouses built in China was initially imported but is now also manufactured locally.

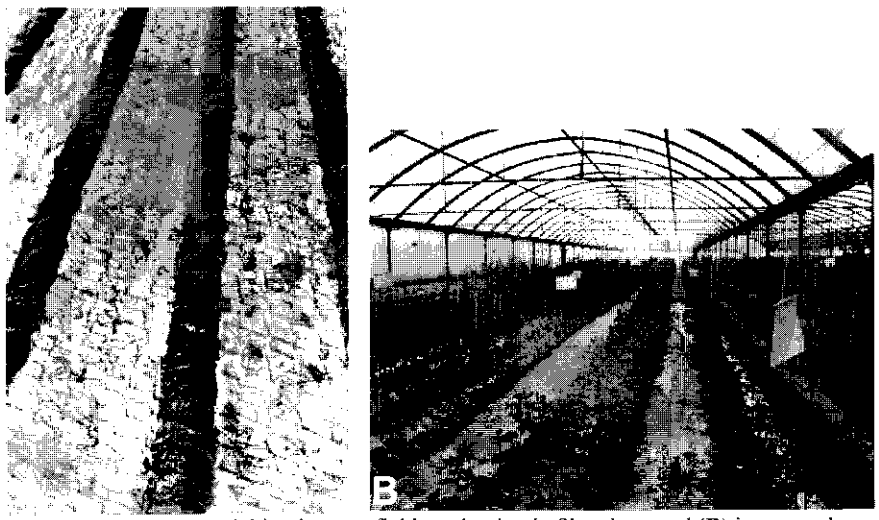

Fig. 2.4: (A) Plastic mulching in open field production in Shandong and **(B)** in a greenhouse in Beijing.

2.3.4 Climate control (heating and cooling)

Heating is very important to decrease incidence of diseases and to increase harvest quality. However, heated greenhouses are not very common in China because they are costly. Less than 5% of the solar greenhouses are heated (Jensen, 2001) and only the modern greenhouses are commonly equipped with pipe heating systems or hot-air heating systems (Dutch Horticultural Board-LNV, 2002). Moveable burners can be also used. The majority of these burners are coal-fired which firstly cause pollution and secondly decrease light transmission due to dust accumulation on the plastic coverings (Dutch Horticultural Board-LNV, 2002). However, since 1999 the use of coal-fired boilers is forbidden in the suburban areas around large cities like Beijing or Shanghai (Jiang et al., 2004).

Pad-and-fan cooling systems are common in modern greenhouses in all the five visited areas. These greenhouses were often equipped with outside and inside screens. In some cases, two inside screens and an outside screen were used (e.g. in Beijing, Shanghai or Shandong). The use of an outside screen reduces light transmission during the summer and the combination of shading with roof sprinkling has been presented as an efficient and energy cheap solution to cool a Venlo-type greenhouses in Beijing (Li et al., 2003).

Initially, most of the screens were imported, but more recently Chinese companies are also providing them.

2.3.5 Soilless cultivation and substrates

Soil born diseases and soil salinity are problems affecting Chinese horticulture and are directly related to the intensive use of soil. Because steam sterilisation is an expensive method (Jiang et al., 2004) and not feasible to apply everywhere (lack of water or electricity) methyl bromide is used for soil desinfection (UNIDO, 1999). According to GTZ (2001) about 2,300 ton were used in 1998 for pre-planting soil disinfection. The largest amount of methyl bromide is used in the production of tobacco seedlings, strawberries and vegetables (tomato and cucumber) and medicinal herbs (UNIDO, 1999). Authorities are searching for alternatives that use less poisonous chemicals (e.g. dazomet, abamactin) or other methods like solarisation, steaming, or different cultivation strategies like crop rotation or the use of new resistant cultivars (UNIDO, 1999). In the solar greenhouses growers close their greenhouses during the summer period making the air temperature rise to about 80°C. The soil is kept humid and is covered with a PE film. In this way the soil temperature can reach about 60°C (Jiang et al., 2004). This procedure should take about 3-4 weeks (Jiang et al., 2004) and although it has limitations it is still a way to reduce the incidence of soil diseases.

The use of local substrates (organic or inorganic) could be another solution. Because of that soilless cultivation is, since 1986, a key project for the Ministry of Agriculture (Zhang, 1999). Even so, the total area remains rather insignificant (1,020 ha) (Chang-ji, 2003).

Between 1986 and 1990 several hydroponic systems (e.g. nutrient film technique or the deep flow technique were introduced in China. However these systems were expensive (many materials had to be imported) or were not adapted to local conditions. As consequence local systems like the Eco-organic Soilless Culture System from the CAAS were developed (Fig. 2.5A). The Eco-organic soilless growing system is cheaper than the imported hydroponic systems, is easy to operate and uses Chinese equipment and locally available substrates (e.g. coal cinder, peat moss, vermiculite, coir, sawdust, perlite, sand, rice husk) mixed with local fertilisers (e.g. chicken manure, corn or sunflower stem powder) (Jiang et al., 2002 and 2004). The system uses solid fertiliser (80-100%) and about 0 to 20% inorganic fertilisers and is independent of power supply (Zhang, 1999). At present, the Eco-organic soiless cultivation represents about 60% of the total soilless cultivated area in China (Jiang et al., 2002; Chang-ji, 2003). This growing system also permits the production of organic products (Zhang, 1999; Jiang et al. 2002).

In 1998, the major location area using soilless cultivation was Shanxi with 130 ha in hydroponics and 120 ha of Eco-soiless cultivation. The provinces of Liaoning, Beijing, Shenzhen are also relevant regarding soiless cultivation (Jiang et al., 2000).

Fig. 2.5: (A) Eco-organic soilless system in a village farm in the outer suburbs of Beijing and **(B)** perlite slabs in a demonstration center in Shanghai .

Only research institutions, demonstration centers or village greenhouse farms are using perlite and stonewool as cultivation substrates. Perlite is gaining importance because it is locally abundant and cheap. China is one of the world largest, if not the largest, producer of perlite (Bolen, 1997), with the province of Henan being the main production area. In Shanghai one cubic meter of perlite costs about € 9 and a 30-litre perlite bag would cost € 0.4 (Fig. 2.5B). Besides being used alone to grow vegetables, perlite is also used in peat-mixes for pot plants like bromelia and as a propagation substrate or as a seed covering of seed plug trays.

High quality stonewool for horticultural cultivation needs to be imported. There are local manufacturers producing stonewool for the construction sector as an insulation material but the quality of this local stonewool is said not to be good enough for greenhouse cultivation. The price of a stonewool slab imported from the Netherlands to Shanghai was €1.6 whereas a stonewool block would cost € 0.1. In addition to the high cost, recycling is another major inconvenience of stonewool in China. Foam (oasis) granules are used in cultivation of cut anthurium and potting mixes for phaelonopsis plants include expanded polystyrene.

Regarding organic substrates, China has peat reserves in the north-east part namely in Liaoning or Heilongjang provinces. The area of these reserves is estimated at about 10,000 km2, with an average thickness of 0.5 to 3m depth (IPPC, 2003). This peat is extracted in the winter when the soil is frozen, hard and dry. The peat is normally extracted after the first layer of 20 cm and until a depth of 3 m. The higher peat layers have high fibre content and are usually used for cutting propagation. The bottom layers, more decomposed, are used for propagation by seedlings. However, high quality (and more expensive) peat is imported from Germany, Denmark or Canada to be used as a propagation substrate for ornamental seedlings or as a potting substrate for ornamental pot plats (e.g. bromelia).

The use of organic wastes like sunflower stem powder, corn stem powder, sawdust, coir, rice husk, mushroom waste as alternative substrates is being investigated (Weijie et al., 2001). Coir for example is largely available in the Southern tropical part of China (Hainan province).

2.3.6 Fertiliser use

The use of organic fertilisers has been decreasing during the last 50 years in favour of chemical fertilisers (Table 2.7). China is the world largest consumer and the second largest manufacturer of inorganic fertilisers (Zeng, 2003). Shandong, Yunnan and Jiangsu are among the five largest fertiliser producing provinces, producing respectively 4.2, 1.95 and 1.87 million tons (ICEX, 2002). Shandong and Jiangsu are also two of the largest users of chemical fertilisers. The Chinese fertiliser market is characterised by a surplus of nitrogenous fertilisers but a lack of potassium fertilisers that have to be imported (ICEX, 2002

Table 2.7: Inorganic and organic fertiliser used in China (in million tons, %).

Year	Total $N+P_2O_5+K_2O$	Inorganic	%	Organic	%
1949	4.3	0.01	0.1	4.3	99.9
1965	8.7	1.9	22	6.7	78
1985	31.5	17.8	56	13.8	44
1990	40.9	25.9	63	14.9	37
1993	46.7	31.5	68	15.2	32
1995	52.9	35.9	68	17.0	32
2000	60.3	42.0	70	18.3	30
2005*	66.3	49.7	75	16.6	25

*Estimated data
Source:PPI (2003)

Soluble and slow release fertilisers are still new concepts in the Chinese horticulture and are mainly used in modern large scale companies and demonstration centers. In this case drip pipes are used for fertilisation. These fertilisers are expensive for small growers. Moreover, they miss know-how to operate the fertigation systems and make the nutrient solutions (Jiang et al., 2004).

The use of organic compost as a fertiliser is expected to rise because it is increasingly recognised as a good economical alternative for waste disposal in China (Wei et al., 2000). But, there are still problems regarding health hazards related to pathogens, heavy metals and organic contaminants that need solving (Wei et al., 2000) and which can postpone their use as vegetable fertilisers.

2.3.7 *Irrigation*

Water belongs to the collective and in general growers can irrigate their crops with water from rivers or wells. China has about 50 million ha of irrigated area, most of them located in Shandong, Jiangsu, Henan, Hebei and Jiangsu (Mangen, 1998). Furrow irrigation is the dominant irrigation method (Mangen, 1998) and is used either in open field or in greenhouse cultivation (Anonymous, 2002c; Yuan et al., 2001). Drip irrigation is mostly done in modern greenhouses but farmers are starting to recognise its benefits (Yuan et al., 2001). The major obstacle to the expansion of drip irrigation seems to be the costs of installation (€ 815-1,220/ha) which can be higher due to the small size of the plots to be irrigated (Mangen, 1998).

Dripping systems are also used to irrigate plants in containers but due to the low labour costs crops are still mainly watered by hand (Wernett, 2000). Sprinklers and mist systems can also be found in modern greenhouses .

The local industry has also developed and expanded but foreign companies, specially the American and Israeli, are very active in China (ICEX, 2002).

2.3.8 Labour

China has plenty of labour to produce and process labour intensive crops like greenhouse vegetables and cut flowers . Wages are rather low, in particular those paid in the farming sector. According to data from the State Statistical Bureau of China for 1999, the farming sector had the lowest annual average salary compared to other sectors in China: € 650. The salaries paid in the sector vary between € 39 and € 59 /month for an unskilled worker in greenhouse or open field, to a maximum of € 79 /month for more skilled work at the greenhouse. Salaries in the commercial industry are higher. For example, the average salary for low skilled personal working for a greenhouse manufacturer was about €160/month. The working period is flexible and there is the possibility of working during the weekends. Therefore, it is difficult to be sure about the precise number of hours a salary can correspond to.

Farmer's income also depends on the location and the type of cultivated crop. In Taian, Shandong, the income of a farmer (household) with a fruit tree and ornamental tree nursery was estimated at about € 985 /year. In the same province, in Shouguang, the average income of a farmer cultivating vegetables in solar greenhouses can reach € 2,995/year. In Shanghai and Beijing, private companies are also offering training to their employees and/or paying according to productivity. In Beijing some of the highest wages in the private sector (e.g. greenhouse technical manager) can reach € 200 /month whereas the salary in governmental companies is about half that. Greenhouses workers get € 50 to € 80.

Regarding high skilled employees, salaries of university teachers and professors can vary between € 295 and € 490 although they may have extra benefits (e.g. health insurance, driver). In a village-company in Beijing the profit of the company is also distributed among the farmers.

Although labour is cheap in China, productivity is far below the world average (Weimin, 2001). This in part relates to low instruction levels, but also to less efficient management. Education and training are thus fundamental tools to increase productivity of the greenhouse horticultural sector.

2.3.9 Logistics

The horticultural business needs a good and efficient transport system specially when the production areas are distant from the consumption centers which is the case in China. Great efforts to develop the transport systems by building major roadways, expressways and rail lines were visible in all the provinces visited. This certainly facilitates the transport of horticultural produce (e.g. flowers and vegetables) between the production centers (e.g. in the South) and the major consumer centers of the country (e.g. Beijing and Shanghai).

However, there are few refrigerated vehicles for the transportation of perishable produce between the different provinces and the majority is used to transport meat, poultry, fish and eggs (Feng, 2001). Consequently vegetables are normally transported by road without refrigeration. For long distance transport crushed iced is placed between vegetables (Feng, 2001). Middle and long range transportation of vegetables is mostly done by train but the large quantities of vegetables often overload the system causing long delays. (Ma et al., 2000).

Flowers for the domestic market are transported by trucks, small vans or motorbikes and for short distances they are simply carried by hand in baskets (Bent, 1999; Dutch Horticultural Board-LNV , 2002). Train transport (with cooling) is also used for cut flower transport namely between Kunming (Yunnan) and Guangzhou (Guandong) (Bent, 2001).

2.3.10 Post harvest technology (e.g. packaging, storage, processing)

In the 80's vegetables were delivered in bulk to city retail outlets, whereas in the early 90's net plastic bags started to be used by farmers and wholesalers (Shields and Tuan, 2001). In the late 90's rigid plastic became more common (Shields and Tuan, 2001) and in the large cities the tendency is to use carton, wooden or plastic boxes for fruits and vegetables (Feng, 2001). However, it was visible in some major supplying markets of Shandong, Jiangsu and in Beijing that products are still commonly packed in plastic net bags rather than in boxes. The packaging of fruits and vegetables in supermarkets was rather carefully done and the presentation was good.

The Chinese supply chain of vegetables (and flowers) also misses appropriate storage facilities as most of the vegetables are still stored in conventional warehouses, underground storehouses and cave houses (Feng, 2001). Moreover, China's cold chain infrastructure (here

defined as the processes and services used to transport and preserve edible products in a controlled-temperature environment) is considered to be old, under-invested and is now under pressure to keep up with the enormous new demand (Burke and Wingard, 1998). Governmental investments gave priority to production and forgot the distribution system. For example, governmental investment in vegetables post-harvest was less than 0.5% of the amount invested in vegetable production (Feng, 2001).

However, the renewal costs of refrigeration or storage infrastructures are rather high and this is a major limiting factor specially when the domestic prices of vegetables are low and cannot cover the investment (Zheng et al., 2001). This remains the case even though losses can reach 35% (e.g. Chinese cabbage).

2.4 Environmental aspects

China's priority on rapid economic growth and achieving high crop yields conflicts in many situations with environmental protection and preservation. Soil and water are two natural resources which are scarce and under strong pressure. China has about 1/3 of world's per capita tillable land (1120 m^2; Sun, 2003) and the problem of soil degradation (e.g. by erosion, compaction or salinity) is large and not controlled (Lal, 2002). According to recent literature China faces a big problem of water shortage, in particular at the North of the Yangtze River Basin (ICEX, 2002; Lohmar et al. 2003, Wolf et al., 2003; Wang et al., 2003). China has about 1/4 of the world average water resources per capita (2500 m^3) and in some northern regions it can be as low as 1/24 of that average (Wang et al., 2003). Moreover, agriculture remains the "major user" of water in China (about 70% of the total) (Mangen, 1998; Genesis Technology Group, 2003) and water-use efficiency is about half of the efficiency of developed countries (Mangen, 1998; ICEX, 2002) due to water losses via evaporation or leakage from old irrigation systems (Mangen, 1998). For several years China gave priority to investments in new projects rather than in the renovation and maintenance of the existing systems, although this is now clearly changing (Lohmar et al., 2003).

Water pollution due to intensive use of fertilisers and pesticides is another problem (Xie et al., 2002; ICEX, 2002; Zhang, 2002; Wolf et al., 2003). A water survey in an intensive cropping area in five provinces in North China showed that in half of the 150 locations investigated, nitrate content in ground and drinking water exceeded acceptable nitrate levels (Zhang, 2002). The excessive use of nitrogen fertilisers on grain and vegetable crops conduces to huge losses of nitrogen every year and about 50% of these losses occur within the Yangtze, Yellow and Pearl River Basins (CCICED, 2002; Zhang, 2002).

China has also become between 1995 and 2000 one of the world's largest users of pesticides. The average use of active ingredient is 250,000 tons/year and the demand is expected to reach 300,000 tons in 2005 (Yanqing, 2000; Hamburguer, 2001). The increased use of pesticides (and fertilisers) is associated with an intensification of agricultural and horticultural production (e.g. greenhouse cultivation) (Table 2.8). The higher severity and easier spread of pests and diseases in

China is also related to the proliferation of greenhouses and plastic structures throughout the country, which provide the ideal environment for carryover from one season to the next (e.g. leaf miner) (Wittwer, 1987; Zhao and Knag, 2000). Moreover, the more frequent exchange of plant material between provinces and agricultural regions also increases the problem of pests and diseases (Ma et al., 2000).

Table 2.8: Inputs of plastic, fertiliser and pesticides for tomato and cucumber production in open field or in greenhouse (under shed) in 1994. Adapted from Ma et al. (2000).

Crop	Plastics (kg/ha)	Fertiliser (kg/ha)	Pesticide (€/ha)	Yield Ton/ha
Cucumber (shed)	903	506	735	60
Cucumber	253	273	51	41
Tomato (shed)	789	587	660	60
Tomato	138	273	52	46

According to the same authors, diseases are a major limiting factor for crops like tomato and cause significative reductions in yield and profit.

A large percentage of the used pesticides is old-fashioned because the new products are not available or they are simply too expensive for the smaller growers. Quality control in the pesticides market needs to be increased because pesticides are being sold under false brand names and even retailers do not know the real content (Yong-gong and Guo-jun, 2002). In 2002, a study done in Yunnan for *the Global Greengrants Fund* revealed that about half of the pesticide distributors were not legally registered or licensed (PANNA, 2003).

Organic production

Central and provincial governments are aware of the problems posed by the excessive use of fertilisers and pesticides. Thus, the *State Council of China* has approved a programme giving high priority to sustainable agriculture (Xie et al., 2002) from which several developing programs have resulted (e.g. "Green Road", "Green Market", "Green Consumption"), with the ultimate aim of promoting organic production ("green food"). Simultaneously and at both provincial and county levels the government tries to implement laws to ban the use of some toxic pesticides (e.g. metadhinphos, parathion, omethoate) (NATESC, 2001). However, law enforcement is not easy in China and the flow of information between central government and provincial or cantonal governments is not always easy and effective. Also the limited number of officials and the scattered production structure makes control actions very difficult (Shoof, 1998). Another aspect, is that farmers are in many cases not aware of the dangers of pesticide use, safety and do not know how to properly apply pest management strategies (Yong-gong and Guo-jun, 2002). According to the same authors, the growing area of vegetables using integrated crop protection (IPM) strategies is less than 5% of the total vegetable area. Even so, IPM has made progress in different provinces and more farmers are applying IPM strategies to vegetable crops (Yong-gong and Guo-jun, 2002). IPM

demonstration and research sites have been set up in Shandong, Hebei, Sichuan, Zhejiang and Fujian (Yong-gong and Guo-jun, 2002) and successful FAO-UN Food programs have been conducted with grain crops (NATESC, 2001). A basic conclusion to take from these projects is that farmers will adopt IPM strategies if that increases profit and does not imply higher production costs. To guarantee the basis of the IPM programmes, the Chinese government constructed forecasting stations under the National Crop Pest Forecasting Net which works together with the provincial stations (Yanqing, 2000). Some of the IPM practices include the use of insect nets or the use of yellow sticky traps to control aphids. Sulphur burners can also be used (Jiang et al., 2004).

The total area of organic farming in China is estimated at 50,000 to 100,000 ha mainly located in Shandong, Jiangsu, Anhui, Zhejiang and Shanghai and Heilongjiang in the North (Kotschi et al, 2000). The number of model-farms fully converted to organic production remains small and farms have normally two-tier production system: organic for exportable cash crops and conventional for the rest (Kotschi et al., 2000).

China exports since 1990 organic products like grain, soybeans, mushrooms, honey, vegetables and herb medicines to countries like Japan, USA, Canada or EU members (Yunguan, 2000). Organic production is certified by the government, through the *Chinese Green Food Development Center* (OFDC). The OFDC also organises workshops for growers, processors, traders and governmental officials (Yunguan, 2000) and since 1999 counts on the support of a new organisation, *The Nanjing Global Organic Food Research and Consulting Center*, which is focused on consulting and extension activities in the area of organic production. OFDC's certification system considers two major grades for organic vegetable production: 1) **AA**: organic food certification standard outside of China and used for exported products which can imply an increase of 50-300% on the export price; 2) **A**: used for products sold in the internal market. It only indicates that the product is produced according to a judicious use of biocides and chemicals. For more detailed information see Gifford et al. (2001).

Plastics recycling and energy saving

Production and consumption of agricultural plastics is about 2.2 million (ICEX, 2002). Therefore, large amount of plastic waste is generated every year (about 700,000 ton). Fortunately China's recycling sector is rather active due to the low labour costs that make it cheap to collect, sort, and recycle different types of waste including plastics (Van Beakering, 1999). Therefore, in several provinces it was said that recycling companies would come to collect the used plastic and would pay about € 0.8 per kg. The plastic used for mulching is the most difficult to recycle and there is an increasing demand for degradable plastic (ICEX, 2002).

Energy saving is another major topic for the Chinese economy and also the greenhouse horticultural sector. China has scarce energy resources (Zhong-fu, 2003) and energy costs can have a great impact on the final production costs of greenhouse horticulture (Baoming and Qiang, 1999). The solar greenhouse was a good solution to save energy but more research is needed to optimise the energy use in the solar greenhouse systems (Zhong-fu, 2003) .

2.5 Marketing and Commerce

2.5.1 The domestic market of vegetables and ornamentals

Free and wholesale markets

After the political and economical reforms started in early 80's the number of free-markets increased dramatically and nowadays almost all vegetable supply is made via free retail or wholesale markets (Ma et al., 2000). Retail markets are farmer's free markets, street markets or road-side markets. The wholesale markets are large, state-owned markets which also act as governmental market regulators (Diankui and Mingchi, 1998).

Wholesale markets for vegetables are located near the production areas (e.g. Shouguang, Shandong province) (Chapter 6), or close to consumer centers (e.g. the *Dazhongsi Market* in Beijing, the *Qilin Ma*rket in Nanjing or the *Cao'an Market* in Shanghai). In 1998, the trade volume of these three markets was estimated at reaching 1.5 thousand tones per day (Diankui and Mingchi, 1998). Usually the growers themselves or intermediaries bring the vegetables to the wholesale markets where the wholesaler deals directly with the retailers who will bring the product to street markets for final sale to the public (Diankui and Mingchi, 1998). .

Wholesale flower markets are also located close to the production centers (e.g. Yunnan has several wholesale markets) or close to the big cities like Shanghai, Beijing, Shenzhen or Guangzhou (Dutch Horticultural Board-LNV, 2002). Florist have also an important role in the distribution of cut flowers and pot plants.

The auction system

The auction system is a recent development in the supply chain of vegetables and flowers in China. The first and largest vegetable auction (*Shenzen Futian Agricultural Products Whole Sale Market*) started in 1997 in Shenzen. Sellers are guaranteed payment before goods are released but they have also to pay a service fee of 4% for the total sale (Jiang, 2002). The criteria for quality are high and they have the technology to check for residues (Jiang, 2002). In December 1999, *The Beijing Laitai Flower Plant Co. Ltd* was the first to adopt the auction system to sell flowers in China (Chapter 3) and in 2003 *The Kunming International Flora Auction* started its activity in the Yunnan province (Chapter 7).

Hypermarkets and supermarkets

There has been a fast proliferation of hypermarkets, supermarkets and convenience stores since the mid nineties. As consequence fresh vegetable markets are loosing their almost untouchable dominant position and are loosing market share to these type of new commercial structures (Moustakerski, 2001). Moreover, city governments are pushing to phase out free (wet) markets to improve hygiene and traffic conditions. Shopping centres and convenience stores area are also gaining market share in the flower business although the percentage is still minimal.

Supermarkets and hypermarkets contributed towards an increase in the product variety and the development of quality brands (Bent, 2002) (Fig. 2.6) and they are forcing the governmental whole sale markets to modernise and improve their products and services. Even so, there are supermarkets without a section for perishable products (Keijzer, 2003).

Fig. 2.6: Vegetables and fruits in a supermarket in Taian (Shandong).

Market prices

Prices of flowers and vegetables show a big annual variation due to the seasonality of production and consumption. For vegetables, prices are highest between January and June and lowest during November (Ma et al., 2000). Flower prices in turn remain high during the winter because the festive periods are concentrated during that period, the Chinese New Year being the busiest. From Spring to Autumn prices fall substantially.

Vegetable prices are also low mostly due to over supply. This trend may continue because production is growing faster than demand due to the governmental incentives for vegetable crops (Shields and Tuan, 2001). There are also situations of overproduction of certain cut flower species (e.g. rose or gerbera in Shanghai) which results in low prices. Moreover, small scale growers have hardly any information about market prices. This gives dealers an advantage and results in lower prices for farmers (Lu, 2003).

2.5.2 Import and Export markets of vegetables and ornamentals

Chinese vegetables (and fruits) are competitive in international markets mostly because of their lower price (Table 2.9) (Shields and Tuan, 2001; Bent, 2002; Snodgrass, 2002). However, large scale exports of vegetables to western countries should be limited over the short term for two major reasons. The first is that standardisation and quality norms regarding trading regulations, post-harvest treatments or packaging still need to be implemented (Bent 2002; Donovan and Krissoff, 2001; Dutch Horticultural Board-LNV, 2002). The second, is because the domestic market appears

to be able to absorb the production of high quality products (fruits and vegetables) (Donovan and Krissof, 2001).

Vegetable exports tripled between 1992 and 2000 when they reached 3.15 million tons (Shields and Tuan, 2001). The major exporting provinces are Shandong, Fujian, Zheijiang, Guangdong, Jiangsu, Liaoning Heilongjiang, Anhuei and Gansu.

Table 2.9: Ratio between prices at Beijing Whole sale markets and Los Angeles (LA) at the end of September 2000.

	Tomato	Onion	Lettuce	Garlic	Eggplant	Cucumber	Carrots
Beijing/ LA	0.16	0.15	0.25	0.22	0.04	0.19	0.18

Source: Shields and Tuan, 2001

In 2000 Japan, South Korea, Russia, Singapore, Indonesia were the most important importers of Chinese vegetables. Japan is the best market for fresh and processed Chinese vegetables because of the large investments made by Japanese companies in the 90's in terms of starting material (seeds) and production and packing technology to ultimately supply Japanese retailers (Huang, 2002). Moreover, the ocean freight service from major Chinese ports to Japan have been improved (Huang, 2002).

Japan is also the major importer of ornamental products form China. In 2001, it imported about 2.4 million tons of cut flowers (Anonymous, 2002b). Moss and fresh foliage are other imported items (Jetro, 2002).

Chinese exports to the European Union are also increasing and in 2000, China was the 5th largest supplier of planting material (unrooted plants, semi-finished plants, indoor and out door plants) to the EU with a total value of 10 million Euro (Eurostat, 2001)

On the other hand China needs to import vegetables and other horticultural products to meet the demands of certain Chinese consumers. China imports carrots, turnips, dried vegetables (peas and onions), frozen vegetables mixes and potato products. Imports of cauliflower, brussel sprouts and lettuce also have increased due to the expansion of the tourist/hotel business (Agrifood-Canada, 2002). Some of the major vegetable suppliers of China are USA and Canada. China imports also cut-flowers, pot plants and starting material for flowers or vegetables from countries like The Netherlands, Israel and the USA. Gardening machinery, fertilisers and pesticides, greenhouses structures and greenhouse components are also imported.

2.6 Starting material: the seed industry

China is the second largest market for seeds and planting material in the world (Table 2.10) and needs about 7 million tons of seeds every year , 50% of which is produced by state owned companies (AgJournal, 2001).

Table 2.10: Estimated values (million Euro) of the commercial markets for seed and planting material for some countries

Country	Market
USA	4,630
China	2,440
Japan	2,032
France	1,110
Brazil	975

Source: http://www.worldseed.org/statistics.html#dom com mark

In 1997, there were about 2,700 state owned seed companies in China and 2000 stock (or elite) seed stations with a total of 80,000 employees (Shian, 1997). At the same time there were 400 agricultural research agencies involved in plant breeding (Fang and Jingfen, 1997). In 2000, the number of large companies was still 2,700 and there were also more than 5,000 small scale seed companies (Koo et al., 2003). Three main seed production regions have in China: one in the Northeast, another in the Shandong province and a third one in the Hebei province (ICEX, 2002). The Chinese seed industry sector can be characterised in the following way:

- A typical governmental administrative structure (Young, 2001; AjJournal, 2001;
- No link between R&D and commercialisation which makes research institutions fully dependent on the scarce governmental subsidies, without or very limited capacity to do good research (ICEX, 2002);
- Small scale, regional (cantonal or provincial) and highly segmented markets (Shian, 1997; Fang and Jingfen, 1997; Young, 2001; ICEX, 2002);
- Lack of good and highly productive cultivars for greenhouse cultivation (e.g. tomato);
- Non-competitive marketing structure (low productivity, low quality and loss-making seed producers persist side by side with more effective seed producers) (Fang and Jingfen, 1997; Young, 2001);
- The physical infrastructure for storage, seed processing and packaging is old-fashioned and technologically inadequate (Young, 2001);
- Fast proliferation of seed companies which are mostly acting as distributors for foreign and Chinese seed companies (Gifford et al., 2002);
- The quarantine system is not transparent (Gifford et al., 2002).

During our visit it was possible to confirm that the government has a controlling position in the sector. Local governments, besides the central government, have a strong influence on the seed business. Seed and research institutes are also "politically relevant" as their results (new cultivars) can have a positive effect on the image of the government activity.

Seed producers need a seed production certificate and dealers need a dealer-certificate issued by the local government. Also, the seed quality and packaging has to satisfy the regulations and the requirements of the *Seed Law of the PR China.* Seed quality is tested at the *Institute of Vegetables and Flowers from the Chinese Academy of Agricultural Sciences (IVF-CAAS).*

The price of foreign seeds is very high compared to Chinese starting material. Therefore, imported seeds/cultivars are mainly issued by governmental demonstration centres, big governmental companies or research institutes.

Relevant politic steps for the sector

In March 1997 China agreed to the 1978 version of the legislation for the *International Union for the Protection of New Varieties of Seeds (UPOV).* As a member, China may apply also for international recognition and seed variety protection for its plants. In turn, China has to respect the protected rights of seeds from other countries. However, China has not signed yet the most recent version of the UPOV treaty which includes a larger range of species (Qing and Branson, 2002).

In December 2000 the National People's congress approved a new Seed Law, a regulation code for the seed industry in China. The *Seed Law* regulates breeding, production, trade and the use of propagation material (seeds, fruits, roots, stems, young plants, leaves). The new Seed Law also provides a legal basis to fight against illegal propagation (Qing and Branson, 2002). However, the major problem seems still to be a guarantee that it will be properly enforced (Gifford et al., 2002). The new Seed law also permits private seed companies to compete with state owned companies (Koo et al., 2003). Here are some of the major characteristics of the new Seed Law (Branson and Qing, 2001):

- It regulates the seed material of seven major crops: rice, wheat, corn, cotton, soybean, rapeseed and potatoes. The seeds need to be examined before commercialisation;
- It stipulates the need of three main types of licenses: production license, management license and a combined production/management license. The commercial seeds other than the seven major types and those specified by the provincial authorities are free of producing licensing;
- It implies that the applicants for licenses have to meet certain criteria in terms of capital reserves, technical staffing, facilities and equipment. This restricts the activity of small and medium size seed companies due to the capital reserve requirement and obligates the small companies to use larger companies (often state-owned trading houses) as agents and seed importers (Gifford et al. 2002);
- It protects intellectual property rights by giving the legal background for court action against illegal propagators;

- It imposes clear label requirements (e.g. name of the importer, serial numbers of the seed import approval file, GMOs should be labelled as such, seed quality standards, treated seeds should be labelled, seeds mixes should indicate the proportion of harmful weeds, etc);
- It imposes new and more complex requirements for GMO crops (more examination of foreign companies before seeds are allowed to be commercialised in the country);

Illegal propagation

Two separate administrative authorities implement China's plant variety protection laws: *The State Forestry Administration* for forestry plants and the *Ministry of Agriculture* which is responsible for all agricultural plants including vegetables (Koo et al., 2003). The Chinese market for planting material is one of the world's largest and is also one of the most difficult in which to assure the respect of breeders rights due to the scattered production structure, limited human resources and ability to pay for new varieties etc. Consequently illegal propagation and the disrespect of UPOV rules still occur in China mostly for those species that are propagated vegetatively such as with carnation (Reinders, 2002). This corresponds to losses of millions of Euros every year! The same problem can be considered for roses and other ornamentals vegetatively propagated and to a lesser extent to seed propagated species.

Chinese authorities are aware of the problem and are trying to improve the situation by targeting, in particular, large scale illegal operations. Recently a breeding company has won a case in court (Rubbert Konijn, pers. comm.) but, it has also been said that these problems should be solved with discretion rather with a lot of publicity and court confrontation. Foreign breeders are now more aware of the potential problems and some are already taking precautions by advertising in local information channels (magazines, TV, demonstration centres) about the consequences of illegal propagation.

Seed trade: provincial seed markets, publicity

The domestic trade in seeds is guaranteed by several provincial markets. Each province has its own seed market. The largest one is located in the province of Hubei. The seed markets are institutions where seed producing companies come together to sell their products to retailers. It is an efficient way to put buyers and seed providers in contact. Representatives of foreign breeders and auxiliary companies (e.g. package design and publicity bureaus) can also be present in the market just like at the *China Beifang Seed Market* which we visited in Beijing (See Chapter 3).

Advertising of branded products in China requires governmental approval (Gifford et al., 2002). Seed companies try to target not only growers but also distributors, government officials, scientists (Gifford et al., 2002). Technical brochures, advertisement in magazines, books and on TV are used. Another marketing strategy is to provide seed management to distributors and provincial and county agricultural officials (Gifford et al., 2002) with educational programs on post-planting.

The best way however to advertise seed products is via demonstration centers which can belong to private seed companies or to the government. The reason is that growers like to see with their own eyes how the crop grows, production in the greenhouse and what the fruits look like.

Seed import and export

Vegetable seeds are the most imported seeds. In 2002, China imported about 4.7 million kg with an estimated value of about € 22 million (Gifford et al., 2002). Thailand was the main supplier of vegetable seeds both in volume and in total value (Table 2.11) but Japan, USA, the Netherlands, Israel, South Korea are supplying the most expensive seeds. The import of vegetable seeds should keep growing and Asian countries like Japan should be the major suppliers because their cultivars are more suitable to Chinese conditions (Young, 2001). More than 90% of the flower seeds used in China are imported (Dutch Horticultural Board-LNV, 2002) and the imports of cut flower planting material, bulbs, turf grass seeds are also very important. According to Young (2001), the turf grass seed market in China is huge (about 6,000 MT per year) and is growing fast due to the expansion of gardening areas in urban areas like Beijing, Shanghai, Guangzhou or Nanjing (See Chapters 3 and 4).

Chinese export of seeds is still irrelevant compared to major seed exporters like USA, the Netherlands, France or Japan. However, this can change as soon as several major weaknesses in the Chinese seed production sector like small land plots, long distance from production bases to export locations, and water scarcity are overcome and production costs are reduced (Gifford et al., 2002). Vegetable seed production is a labour intensive process and China has great availability of low cost labour and good climate conditions (Yunnan or Shandong) for seed production. Moreover, the confidence of foreign breeders to release their parent lines needs to increase.

Even so, many multinationals are already active in China. In the vegetable sector for example there are several companies from countries like Japan, USA, The Netherlands, Thailand, Taiwan, South Korea, France, Israel.

Recently, the Chinese government implemented new guidelines for foreign investment in the seed industry. The last changes forbid foreign investors to invest in biotechnology and some specialists of the sector believe that this measure was a combined decision by the Chinese agricultural authorities and research scientists to slow down the advance of foreign seed companies (Gifford et al., 2002). Public-private research collaboration in biotechnology or plant breeding research is still very unusual in China (Pray, 2001).

Table 2.11: Volume and value of vegetable seed imported by China (imports) or exported by China (Exports) from and for the 13 most important trade partners in 2001-2002 (1€=1.23 $US)

IMPORTS			EXPORTS		
Country	**Volume (1,000kg)**	**Value ($US1,000)**	**Country**	**Volume (1,000kg)**	**Value ($US 1,000)**
Thailand	2,306	2,346	South Korea	1,643	4,018
Australia	874	1,868	The Netherlands	409	2,625
Japan	649	8,190	Japan	302	1,971
USA	231	3,201	USA	170	7,439
New Zealand	179	244	Taiwan	155	610
Denmark	124	556	North Korea	81	103
South Korea	102	3,509	Germany	71	70
The Netherlands	69	2,744	Thailand	68	98
Germany	66	165	Hong-Kong	66	61
Taiwan	59	1,784	Mexico	64	140
France	10	669	France	49	418
Hong-Kong	2	46	Singapore	40	67
Israel	1	2,335	Malaysia	39	129
Overall total	**4,675**	**27,760**	**Overall total**	**3,291**	**19,217**

Source : Adapted from China Costumes

The more frequent type of co-operation between the Chinese public breeding research institutes and foreign investors is to work together to identify potential cultivars from outside of China (Pray, 2001). Almost all the foreign companies do this type of research. However, because there is no crop breeding program established by foreign companies, the effective research collaboration is very limited.

Moreover, foreign companies typically collaborate with Chinese companies because the Chinese law requires them to have a local joint venture partner (Pray, 1999). According to the same author three major political changes should favour co-operation between private and public seed sectors:

- Allow the private sector to play a larger role in the distribution of seed and pesticides State owned companies are allowed to sell seeds of major field crops and 80% of the pesticide distribution is controlled by the government;
- Increase intellectual property rights and better enforcement of the existing breeders rights legislation;
- Make the process of approval/disapproval of new varieties more transparent and less dependent on political or economical pressures.

Formerly seed research and breeding centres were financed by the *Academy of Agricultural Science* and/or other research institutes They provided their new varieties free of charge to the provincial and county seed companies. Now the state-owned seed system is becoming more

commercial (Young, 2001; Pray 2001). Seed breeding and research centres have established commercial enterprises to earn money. In many cases they have become owners of seed companies and nurseries (Pray, 2001).

The research centers have created their own marketing and sales teams to sell their varieties to seed production companies and they are undertaking contract work for the future development of new cultivars. This more commercial approach should increase competition among seed breeding centres and consequently the quality of the seeds. Such type of activity was seen at the IVF-CAAS in Beijing and in the *Vegetable Institute of the Shandong Academy of Agricultural Sciences* in Jinan.

2.7 Research, Education and Extension

2.7.1 General characteristics of the University

During the years of the Cultural Revolution, University education and post-graduate training were seriously disrupted. According to Zweig (2002) the Cultural Revolution period "starved" China's Universities in two major ways: by stopping scholarly exchanges with the West and by decreasing University employees wages.

The post-Mao period saw an explosive growth of the number of Chinese students and lecturers going abroad (Zweig, 2002). The number of students going abroad increased almost 10 times during the last two decades (2,124 in 1980 compared with 23,749 in 1999) (Zweig, 2002). Moreover, Chinese universities adopted the strategy of inviting several foreign lecturers to improve the image and the quality of their courses. Co-operation with international partners is also common in the horticultural sector (Hang, 2000). As a consequence, China's science and technology sector became one of the most international sectors of the Chinese society (Zweig, 2002). On the other hand there was also a drain of intellectuals from Chinese Universities to foreign countries (e.g. USA) although many have returned to China.

The period after the Cultural Revolution was also characterised by the rise of a competitive class of young scientists who managed to gather important positions in the academies even that this brought some conflict with the old generation (Cao and Suttmeier, 2001).

Although there have been great changes, the Universities and the educational programmes are still controlled by central government and there are certain limitations on people's mobility (SPI, 2002). The system remains rather hierarchical and students adopt in many cases a rather passive attitude. Furthermore, the wages of Chinese scientists remain low compared to the salaries paid by the private sector and this makes it difficult for the scientific institutions to keep their best scientists (Cao and Suttmeier, 2001). This is particular true in the information technology sectors.

Access to University is still rather restricted especially to the young population coming from the rural areas who have a great disadvantage compared to their urban counterparts regarding the capacity to pay the educational costs (Table 2.12).

Table 2.12: Indicative University fees and duration according to the type of study.

Level	Duration (years)	Fee (€ year^{-1})
BSc	4	985
MSc	3	490
Ph.D.	3	99-197

Source : Anning pers. communication

2.7.2 Agricultural education and research

The three major agricultural research thrusts in China come from by the Ministry of Agriculture, the Provincial Commission of Science and Technology, and the Department or Bureau of Agriculture (ISHS, 2003). Horticulture research is conducted by two groups of institutions (ISHS, 2003): 1) Research institutes and research stations under the Ministry of Agriculture and the *Chinese Academy of Agricultural Sciences (CAAS)* and 2) *Provincial Commission of Science* and *Technology, and Department or Bureau of Agriculture.*

The governmental research institutes are being progressively transformed into private enterprises in order to increase efficiency, output quality and profitability (SPI, 2002). This is the case of *the IVF-CAAS.* The process will reduce governmental funding and force institutes to apply for governmental money by presenting project proposals in competition with other institutes proposals. There are also restrictions in the admission of new personnel.

The large state-owned farms or demonstration centers do not commonly invest in academical research. Instead, they are receptors of governmental subsidies which pay simply their running costs rather then any other innovative development. This results in less money available for academical research and innovation and maintains artificially low the production costs and the price of the final product (vegetables or ornamentals).

Agro-Technical Schools

In 1998 there were 365 agro-technical schools throughout all of China. Together they had more than 40,000 teachers and about 440,000 students (Diamond, 1999). The educational system is being reformed, by changing teaching methodologies, updating knowledge and skills of the educators and by motivating them to make improvements (e.g. study visit abroad for example) and increase students enrolment in educational activities by distinguishing outstanding work with provincial and national awards (Diamond, 1999).

2.7.3 The extension system

The Chinese agricultural extension system is the largest in the world (about 400,000 employees!) and has been frequently considered a governmental instrument to implement agricultural politics. In many cases, the new programs have been implemented as political campaigns (Yonggong, 1998).

It was seen as a typical top-down extension method in which the farmer had a passive attitude (Yunguan, 2000). The extension programs were mainly focused on the transfer of technologies from research institutes to production centres and with the strict focus to increase grain production. After the reforms in the 80's governmental decisions were more market based and shifted from central planning to a more decentralised structure (Yonggong, 1998). The public extension services is composed of different types of institutions working at different levels: national, provincial, prefectural, at county level and township level (Bartholomew, 1994).

According to Yonggong (1998) the 1880 county extension centres are probably the most important in terms of governmental investment. Their functions include: 1) managing and planning extension, 2) conducting extension work on crop cultivation, 3) soil and fertiliser use, 4) pest management and 5) seed quality control, 6) organising demonstrations and trials, 7) training farmers and township technicians, 8) providing assistance for purchasing production inputs or 9) marketing agricultural products.

The township station is working directly with farmers and is focused on on-site advice, training and supervision for new technology adoption, providing information and developing technical handouts for farmers and assisting village farmers' associations.

High Tech demonstration centers

To increase efficiency of the extension services and facilitate transfer of know-how on modern greenhouse production technologies and other a spects like integrated crop protection, environmental friendly agricultural practices, the government has installed several Agri-centers or *High-Tech Agricultural Development Centres* (Bent, 2002c). The Agricenters aim to connect different sectors (production, applied research, training and extension services, landscaping, transport and logistics, marketing and tourism) and increase public awareness of modern production technology (Bent, 2002c). These centers were also used to test new cultivars (Shields and Tuan, 2001; Sonneveld, 2002).

2.7.4 Agricultural education via TV, internet and magazines

The *China Agricultural Broadcast and Television School* (CABTS) was set up in 1980. CABTS' allows distance education in agricultural and is strongly supported by the central and local governments. This service focuses on serving rural areas, agriculture and farmers by providing education and training services to diverse types of audiences, including youth, village leaders, agricultural technicians, women, ethnic minority group members, and farmers ranging in education levels from those who cannot read or write to those working towards university degrees (CABTS, 2003).

Also in June 2000, the *China Distance Education Network* (www.crdenet.net.cn) was officially created. It works as a internet-based information network, which can become an important

tool in the CABTS distance education delivery system (CABTS, 2003). The Chinese also possess an impressive large amount of books and magazines (scientific and technical) related to horticulture and agricultural sciences. In many cases they are published by the Universities or research institutes. Unfortunately, they are not available in English.

2.7.5 Present and future R&D areas related with the agriculture and horticultural sectors

Greenhouse technology and intensive greenhouse production: this topic has been considered by the Ministry of Science and Technology as one of the relevant projects for the *X Five Year Plan* (2001-2005) (ICEX, 2002)

Development of bio-resources: This research topic has become a scientific economic priority for the Chinese government. This work consists of collecting, cataloguing and conserving species in gene banks and making preliminary evaluation of the potential for commercial development (Bent, 2003). Gene banks have been established in Institutes in Beijing and Shanghai and in the provinces of Yunnan, Shandong, Guandong, Jiangsu and Zhejang (Bent, 2003).

Vegetable and flower breeding: China still lacks new, well-adapted and productive cultivars for protected cultivation conditions (Shijun et al., 1998). As a consequence many cultivars used for open field cultivation are used in protected cultivation.

Breeding of vegetable crops in China should be focused on obtaining new cultivars better adapted to low temperature and/or low light conditions (Yongchen et al., 1997; Shijun et al., 1998) and more resistant to diseases (Shijun et al., 1998; Bent 2002b). This was confirmed during our visit to the *Vegetable Institute of the Shandong Academy of Agricultural Sciences*. Research in resistance to water stress or to salinity should also emerge as important topics of research especially with respect to the problems of lack of water in North China.

Biotechnology and breeding vegetable crops: The Chinese government has given high priority to research on molecular biology, plant genetics, biotechnology, and related fields in order to increase crop yields. By the mid 1980s a major national biotechnology program was initiated and did not stop at concerns about environmental risks. Chinese research centres have since begun to develop advanced biotechnological tools such as recombinant DNA technology (The Economist, 2002).

In 2000 the Chinese government invested about € 32 million in plant biotechnology research sustaining one of largest public agricultural science programmes in the world (The Economist, 2002). The development of GMO_S was focused on grain crops but also there are cases for horticultural crops (e.g. late ripening tomatoes, virus resistant sweet pepper, coloured petunias) which have also been approved for commercial cultivation in China (The Economist, 2002). The biotech sector however, seems to have several problems: 1) funding is almost exclusively governmental; 2) there is a lack of good management (lack of people combining good management kills and vision with science) and finally 3) lack of intellectual property protection (The Economist, 2002).

Sustainable development: The environment and sustainable development are very important matters for the future of China with respect to the huge population and the lack of natural resources (land and water for example). Therefore on this area we may have promising research topics related to environmentally friendly agricultural practices, water and soil management, etc.

3.

Beijing municipality

by J. Miguel Costa and Oliver Körner

Abstract

Beijing has a resident population of 12 million inhabitants and one of the highest GDP per capita of whole China. It is therefore one of the most important markets for vegetables and ornamentals in China. Beijing is also a good example of (peri)urban horticulture as vegetables, cut flowers and pot plants are produced in open field or greenhouse in the municipality. In 1999, the total vegetable production area was estimated in 94,000 ha and in 2001 the area of ornamentals was estimated in 67,000 ha. At present, the protected cultivated area is estimated in 14,000 ha, 70% of which occupied by plastic tunnels and the rest by solar greenhouses mostly growing vegetables. Modern greenhouses (plastic multispan or glass Venlo type) are used by demonstration centres, research institutions, village farms or large state owned or private groups (e.g. from Taiwan). They are mainly growing pot plants (bromelia, petunia, phalaenopsis). Vegetables are sold via free markets, whole sale markets but also supermarkets and hypermarkets. The market of flowers, pot plants and garden plants is large and develops fast. In 2001, about 300 million fresh flowers and 30 million pot plants were sold in Beijing. The demand for garden plants also increased due to the fast expansion of the garden area in the municipality. Several relevant agricultural research institutions like the *Chinese Academy of Agricultural Sciences (CAAS)* or the *China Agricultural University* are located in Beijing. The future of greenhouse horticulture in Beijing should pass by an increase of ornamental production and mostly of flowering pot plants. The demand for higher quality vegetables should also increase due to the expansion of the tourist sector (restaurants and hotels). Garden plants will be also in great demand due to the preparation of the Olympic Games in 2008 although they should be imported from other provinces Jiangsu and Shandong

3.1 Introduction

3.1.1 Characterisation of the municipality

Beijing, the capital of the People's Republic of China, is an independently administrated municipality located in the north of the Huabei Plain (North China) between 115°- 117° E and 39°-41° N (Fig. 3.1A). Beijing covers an area of about 16,800 km^2, stretching 160 km from East to West and more than 180 km north to south.

With a resident population of about 12 million people and 3 million migrant workers, the municipality has one of the highest population densities of China (about 890 inhabitants/km^2) (Royal Netherlands Embassy, 2003). Beijing belongs to the warm temperate climate agricultural zone (Chapter 2) and has a continental climate with cold and dry winters and hot summers. January is the coldest month with minimum temperatures of about -10 °C, whereas July is the warmest with maximum temperatures above 30 °C. The frost-free period is about 180 days (Huang, 2003) and there are 13 days with closed snow cover. The average amount of sunlight hours is 2,700 h per year whereas the average total annual precipitation is 638 mm. More than 60% of the precipitation falls in July (217 mm) and August (169 mm) (Fig. 3.1B). The relative humidity is maximal between July and September with values that vary between 70 and 79%.

Beijing has one of the three highest annual GDP per capita (€ 3260) of whole China which is clearly above the country's average GDP per capita (€ 740) (Royal Netherlands Embassy, 2003). It may be considered one of the most modern and open to the outside world cities of China.

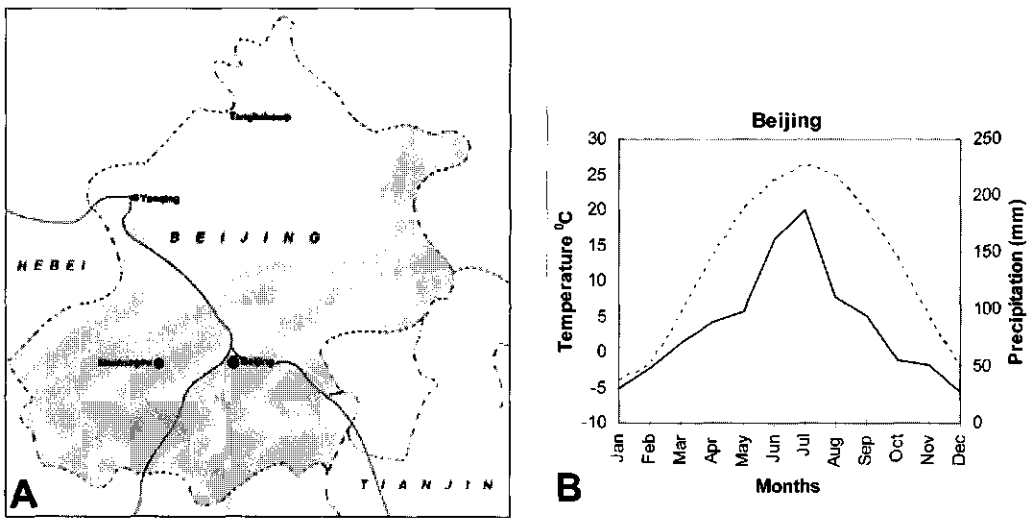

Fig. 3.1: (A) Map of the Beijing municipality (http://www.maps-of-china.com) and **(B)** average temperature (--------) and precipitation (——) in Beijing (http://www.fwcc.org/climate.htm).

3.1.2 Horticultural sector profile

Beijing represents one of the largest consumer centres of vegetables and ornamental products in China. In 2001, vegetable consumption was 1.148 million tons (Li, 2001). The demand has increased, due to increased consumption per capita and increased urban population. Besides being a large consumer centre, Beijing is also a good example of urban agriculture. The vegetable cultivated area increased from about 91,000 ha in 1995 to about 93,500 ha in 1999, while the production rose from 3.97 million tons in 1995 to 4.89 million tons in 1999 (Li, 2001) In 2001, the area of ornamentals was estimated at 67,000 ha (Wolf et al., 2003).

In 1999 the cultivated area in greenhouse was 10,000 ha (Li, 2001). At present this area is about 14,000 ha (Sun Zhong-Fu, pers. comm.). From these 300 ha correspond to modern multispan greenhouses, 4,000 ha are solar greenhouse (lean-to type) and 10,000 ha are plastic tunnels (Sun Zhong-Fu, pers. comm.). Vegetables are grown in about 90% of the tunnels and the solar greenhouses. The remaining area is cultivated with flowers and fruits. Regarding the multispan greenhouse, 40% are dedicated to flowers and pot plants and the remaining to vegetables and different types of melons (Sun Zhong-Fu, pers. comm.). Due to the fast expansion of the city, the production areas for vegetables and ornamentals are forced to the outer suburbs to *satellite* cities in the counties of Daxing , Yanqing or Shunyi (Girardet, 2002; Wolf et al., 2003). The progress in the transport infrastructures (e.g. better roads) also facilitates this move to the outer suburbs. In fact, in the neighbouring counties of Beijing, vegetables represent already 17-30% of the total cropping area (Zhang, 2002).

Like other provinces/municipalities the production structure is based on small scale farms and the large scale operations belong to state or private owned companies or high-tech demonstration centres.

3.2 Production Systems

3.2.1 Product diversity and quality

The diversity of vegetables offered on the market is large (>100 species). The most important are Chinese cabbage, tomato, cucumber, pepper, cauliflower and different kinds of melons. Anthurium and chrysanthemum (as cut flower and pot plant), cyclamen, and bromelia are among the most important ornamental species produced in greenhouses in Beijing. The area seems also suitable to grow roses as the climate (low night temperatures) favours development of large flower buds which have good acceptance in the market.

According to Post and Zhang (2003) there is a limited number of garden plant species. In fact, during our visit it was possible to see that a certain group of species was systematically used in city gardens namely cedar, salix, ginkgo, lagestroemia, juniperus, berberis, buxus, rosa, azalea, euonymus.

Vegetables are commonly produced in small or large tunnels or in solar greenhouses and destined to local markets but high quality lettuce was produced in a modern greenhouse on a contract base to supply a US *fast-food* chain. Vegetables are also produced in an organic way. In this case, soil, air and water have to be analysed and the products have to be tested by the *Green Development Centre* (quality inspection). The certification of organic produce can be achieved for 3 years. Surprisingly, there is only a little market-price difference between organic and non-organic production. However, when products are sold to supermarkets or hotels, 30-40% higher prices can be achieved compared to non-organic products. The organic production base visited in the outer suburbs of Beijing (Pinggu district) was mainly exporting to Japan, which is known to have high quality norms regarding pesticide use. The organic products of this company were classified as A; the AA classification (see Chapter 2) was not attained due to problems related with packaging.

Regarding ornamental crops, pot plants (e.g. bromelia, cyclamen, anthurium) or cut flowers (e.g. roses and anthurium) are produced in modern and highly equipped greenhouses. The quality of pot plants and cut anthurium was in general good.

3.2.2 Production methods

Vegetables are mainly grown in soil, either in open field or in greenhouses. Small farmers cultivate vegetables outside or in small plastic tunnels or very simple greenhouse structures (Fig. 3.2). The solar greenhouses are normally used to grow tomatoes, cucumbers or peppers. The large companies use modern solar greenhouse structures, with brick walls and metal structure and with drip irrigation. The company visited in the Pinguu district had 50 of this structures (Fig. 3.2). Due to the excessive high temperatures during the summer (July and August), cultivation in the solar greenhouses stops during that period. The greenhouses are then closed and made empty. By closing the greenhouse temperature inside can rise until 80°C which is considered a relatively good way to disinfect the air and soil (See point 3.2.6). Plastic mulching is often used in both solar greenhouses and the multitunnels. White coloured plastic is used during winter, whereas black plastic is used during the summer and spring. The white transparent plastic mulch keeps the soil warmer, controls weed growth and reduces water loss (Fig. 3.2).

The crop cycle and indicative yields for some important vegetable crops grown in solar greenhouse are presented in Figure 3.3 and Table 1.

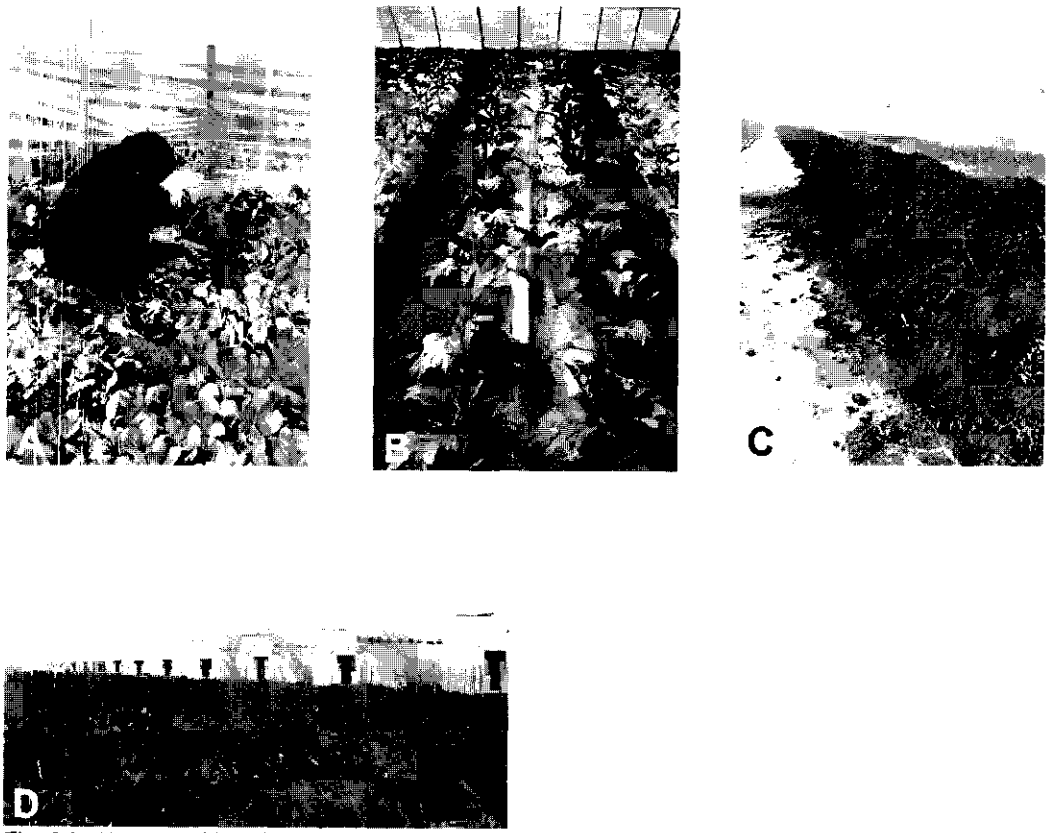

Fig. 3.2: **(A)** Vegetable cultivation outdoors or in small plastic tunnels by small farmers in Beijing and **(B)** mulching in a solar greenhouse; **(C)** organic compost to be incorporated in the soil beds and **(D)** a serie of modern solar greenhouses

1st planting	Harvest		EMPTY		2nd planting	Harvest
I----------I		I---------I		I---------I	I---------I	I----------I
February	**May**	**June**	**July**	**August**	**September**	**Nov.-Feb.**

Fig. 3.3: Crop cycle for pepper production in a solar greenhouse located in the outer suburbs of Beijing .

Table 3.1:. Annual yields from 3 major crops grown in soil, in a solar greenhouse in the outer suburbs of Beijing.

Species	**Yield (kg/m^2)**
Pepper	10 [a]
Cucumber	7-10 [a]
	14-20 [b]
Tomato	20 [b]

[a] Whole year
[b] Two crops a year

Vegetables are also produced in multi-span glasshouses belonging to governmental institutes, demonstration centres, or *model-villages*. In this case production can also be done in the eco-soilless substrate (see Chapter 2). In the so-called "Model Village" (*Hancunhe Tourism Scenic Village*), tomato production was estimated at 15 kg/m^2/year, using 2 crops a year. Trellising was used for tomato and cucumber production in solar greenhouses and organic fertilisation is done with organic compost produced on the farm (Fig. 3.2). Colour plates were used in the modern greenhouses as well as in solar greenhouses but no signs of biological control were seen. Sulphur burners were also used in a solar greenhouse of CAAS producing poinsettias.

In the modern greenhouses pot plants were grown on movable benches and without assimilation lamps. Specialisation to one crop only is very seldom for both vegetable and ornamentals. Some companies combined cut-flower and pot-plant production with garden plants.

3.2.3 Starting material and propagation

Vitro propagation of phalaenopsis seems an important business activity in the municipality. Both governmental and private companies are present in this sector taking advantage of the low labour costs. A private company owned by a Taiwanese group has a total of 400 employees half of which (all female) is allocated to propagation activities. The company propagates and produces 5 million plants every year (Fig. 3.4A), which are exported to the USA, South Korea, Japan or France (Fig. 3.4A and B). The starting material for cut rose or anthurium production is mainly imported from The Netherlands or France via Chinese agents, whereas the starting material for chrysanthemum production comes from Japan.

Regarding vegetables, 80% of the seeds sold by the provincial market are coated and seedlings are raised in substrates like peat. In more specific cases, like the lettuce cultivated in the floating system, seedlings are germinated and grown in small foam cubes which are further transplanted to floating polystyrene plates. Several ornamental garden shrubs and trees are propagated in vivo by stem cuttings either inside or outside the greenhouses as it was observed at the *Forestry Institute*.

Fig. 3.4: Propagation in-vitro and production of pot phalaenopsis in the suburbs of Beijing. **(A)** View from the propagation lab and **(B)** greenhouse facilities where the young rooted material is transplanted into pots, hardened-off and finally grown until being sold.

3.2.4 Greenhouse structures and equipment

Many different types of greenhouses exist in Beijing: Plastic multitunnels (with a simple or a double-layer inflated cover), polycarbonate greenhouse and glasshouses. The single plastic tunnel and solar greenhouses (lean-to type greenhouse) are the most common types. The first is used because it is cheap and simple to built. The solar greenhouse is used because it is well adapted to the Beijing climate, has minimum energy consumption and construction costs/m^2 are low compared to multitunnels or other more modern structures (see Chapter 2). In Beijing, during winter when minimum outside temperatures can reach -10°C or even less the inside temperature in a solar greenhouse can be maintained at around 7 or 8°C. During summer, the outside temperatures can rise to 36°C and the inside air temperature may reach 39°C. In this situation , the north wall of the greenhouse has several openings that can be open for cooling in addition to the regular ventilation (Figs. 3.5 A and B). To cover the solar greenhouses or multispan greenhouses, growers use PE or PVC with a lifetime of about two years.

Like other Chinese provinces, Beijing has imported many modern greenhouses from abroad. Multi-span houses with different roof materials are present and the size of those greenhouses is usually between 1 and 2 ha (Fig. 3.6). As an example, the greenhouse complex belonging to the "Model Village" consisted of several types of greenhouses: Venlo type, polycarbonate multitunnels (imported from USA) and solar greenhouse types. The polycarbonate multitunnels were equipped with a pad-and-fan system.

The design of greenhouse structures should be adjusted to each climatic condition (Von Zabeltitz, 1999). However, many imported greenhouses in Beijing are only little adjusted and in many cases the structure did not differ from the originals (e.g. in The Netherlands). This has been one the problems with some of the characteristics of the imported Venlo-type glasshouses since

they were not designed for the continental climate that prevails in Beijing (cold winters and hot summers), and which differ from the Dutch moderate climate (Table 3.2).

Nevertheless, the most recent greenhouses are better equipped (e.g. with inside and outside screens, pad-and-fan cooling) and thus better adjusted to Beijing's climate. Some of the greenhouses visited in the outer suburbs of Beijing used in pot plant production, had gutter heights of 2.8 m and a span-width of 7.0 m. Those structures were built by a Chinese company and had a double air-inflated plastic cover and polycarbonate side-walls. They were also equipped with a pad-and-fan system and an outside screen (Figs. 3.5A and 3.5B). Other structures had a polycarbonate roof which improves light transmission and increases the greenhouse life time (until 15 years). The costs of a complete polycarbonate structure is the double of that of a structure with polycarbonate walls and a double PE-foil roof (Table 3.3). In Beijing, light is usually not considered a limiting factor for vegetable cultivation (about 1,000 hours more than The Netherlands). However, a big company in the Pinggu district cultivating vegetables in solar greenhouses is considering the possibility of using assimilation light regardless the increase in energy consumption.

Table 3.2: Characteristics required for heating, wind resistance and resistance to snow load in a greenhouse in The Netherlands and Beijing.

Location	Outside Temp. (°C)	Inside Temp. (°C)	Heat load (W/m^2)	Wind load (KN/m^2)	Snow load (KN/m^2)
The Netherlands	0	15	263	0.536	0.25
Beijing	-12	15	463	0.28	0.30

Source: Chang-ji (2003).

Table 3.3: Indicative prices per square meter for Chinese made multispan greenhouses visited in the Beijing municipality.

Covering material and equipment	€/m^2
Polycarbonate side walls and cover, With irrigation system and fan and pad, internal and external screens	59
Polycarbonate side walls, double plastic cover, With irrigation system, fan and pad, with internal and external screens	29.6

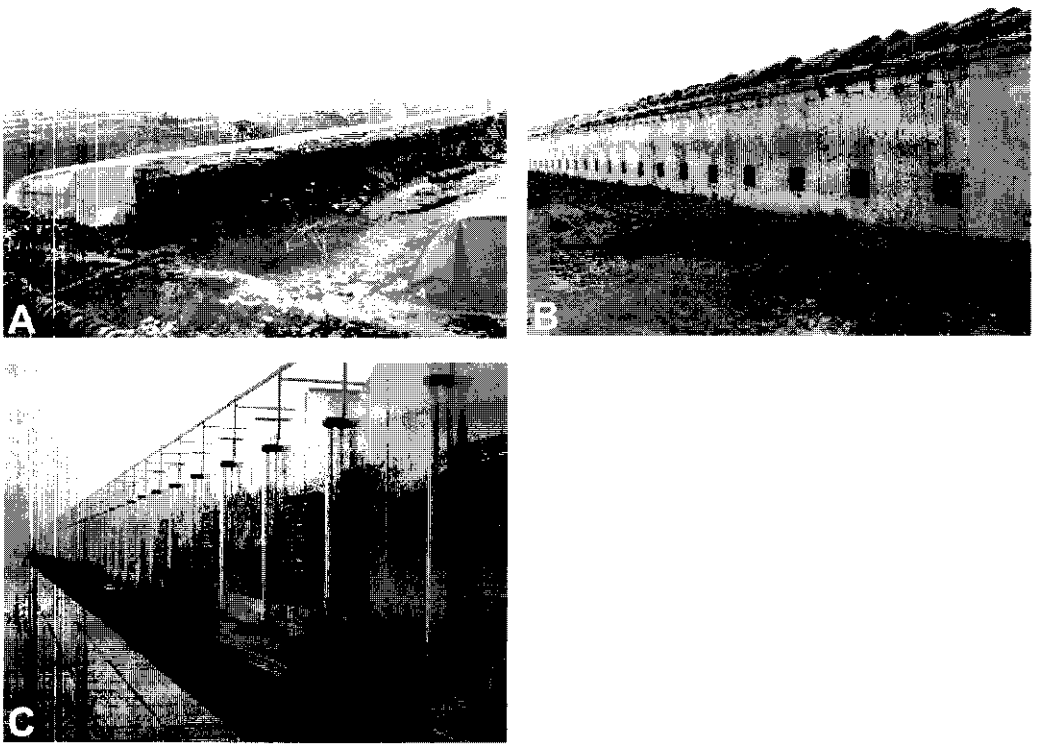

Fig. 3.5: (A) View from a solar greenhouse in the suburbs from Beijing; **(B)** Openings at the north wall of the greenhouse; **(C)** Modern greenhouse structures in Beijing equipped with a pad-and-fan cooling system and an outside screen.

3.2.5 Substrates and plant nutrition

Cultivation in soil is the most common practice in Beijing. Substrates like stone-wool or perlite are only used in modern greenhouses belonging to large companies, research institutes or demonstration centres. In an agro-tourism and high-tech demonstration centre (*Beijing Glorious Land Agriculture Co.)*, lettuce and celery are cultivated in a water floating system in which expanded-polystyrene plates float on a nutrition solution and serve as support to the plants (Fig. 3.6A). In the Model Village (*Hancunhe Tourism Scenic Village)*, tomatoes are cultivated in the so called eco-soiless organic substrate (See Chapter 2). The use of artificial substrates is more common in ornamentals. For example, foam is used to grow cut anthurium just like in The Netherlands (Fig. 3.6B). This inorganic substrate is produced in southern China. For pot plants like bromelia, a mix of peat and perlite is used and for young rooted plants of phalaenopsis a mix of sphagnum and expanded polystyrene is used.

The use of compost and organic fertiliser is increasing in Beijing due to the expanding area of parks and gardens around the city and to governmental programs for tree plantation along the main

roads as a way to mitigate pollution problems. Moreover, the area occupied with (turf) grass increases the demand for specific fertilisers. Because of that, several companies (state owned and private) have recently entered the market. The use of organic fertilisers in protected cultivation is still limited (1-5% of the total production of 100,000 m^3/year).

One composting company, private owned, has a production capacity of 5,000 tons/year and produces basic organic fertiliser for vegetables, flowers, lotus and fruit trees. The company uses simple technology and work is mostly manual. Waste from mushroom production (e.g. cotton-tubes) and chicken manure are the basic products of the compost mix. The private company has a close relation with the IVF and the office of the mother company is located in the complex of the *Chinese Academy of Agricultural Sciences* (CAAS) in Beijing. Another company was co-operating with a Canadian company which would provide the technology and information about the compost contents.

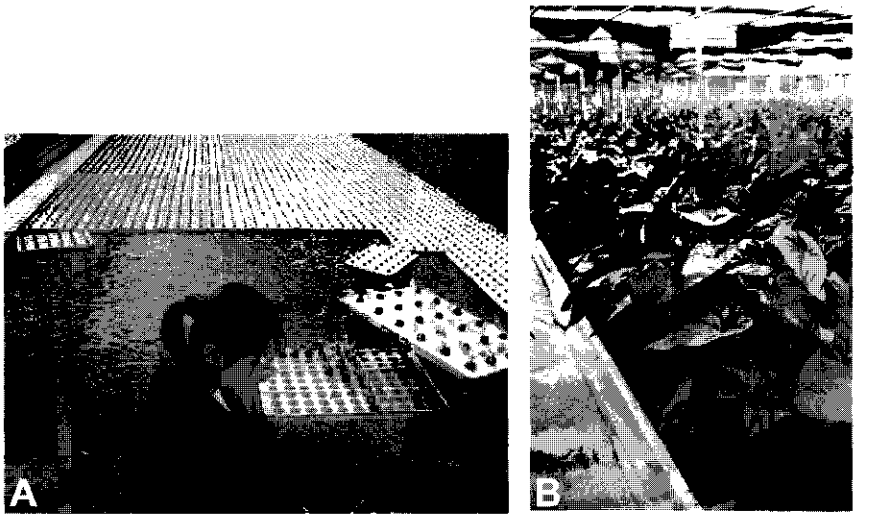

Fig. 3.6: *Different types of soilless cultivation systems in Beijing:* **(A)** *lettuce growing on a floating system and* **(B)** cut anthurium grown in foam granules.

3.2.6 Water and environment

According to recent literature, the quality and availability of water is an important issue for the Beijing municipality (Wolf et al., 2003). Both quality and availability is decreasing due to the rapid urbanisation and intensification of the agricultural production (Wolf et al., 2003). Agricultural intensification is visible through the increasing cropping area of vegetables in the last decades (substitution of grain crops by vegetables growing in open field or greenhouse). However, water has not been mentioned as a limiting factor during our visit and all the visited companies had their own wells and some of the most modern companies were collecting rain water from the greenhouse's roof, too.

In the simple greenhouses (tunnels and solar greenhouse) watering of crops in soil is commonly done by hand or by furrow irrigation, whereas the modern greenhouse structures use hydroponics or fertigation. Pot plants are also watered by hand and/or by sprinklers (e.g. when growing on elevated benches).

Soil desinfection is carried out with the use of chemicals like methyl-bromide although other chemicals like abamactin or dazomet are being tested. A kind of solarisation can be used in solar greenhouses during summer. The greenhouses are closed, the soil is made humid and covered with a plastic film. which provokes a soil temperature rise up to 60°C according to Jiang et al., 2004). The disinfecting effect can however be limited (see Chapter 2). The use of plastic mulch either in solar greenhouses or more modern multispan greenhouses avoids herbicide application but also generates great amount of residuals. The old plastic covers from greenhouse are easier to recycle and they are sold at € 0.69-0.99 per kg to recycling companies. These companies collect the material directly from the farmers. The compost producing company was also aiming to reuse their old plastic bags.

3.3 Marketing, commerce and logistics

Vegetables are sold at street markets, retail-wholesale markets and supermarkets. Vegetable distribution is assured at present by about 20 wholesale markets scattered over the city. The most important is the *Dazhongsi Wholesale Market.* Supermarkets chains are becoming increasingly important in vegetables supply with Chinese and foreign groups (e.g. *Carrefour* and *Metro)* sharing the market. Prices of hypermarkets and supermarkets are higher than prices of free markets (street markets) (Fig. 3.7A) but have the advantage of better hygiene and product quality (presentation, packing and more guarantee of residues free). Between late autumn and early spring three major regions (west-central China, the north China plain and south China) supply Beijing with vegetables and complement the local production. In autumn, vegetables are imported from west-central China, whereas in winter they are transported from the North China Plain and south China (Shields and Tuan, 2001).

Regarding the ornamental sector, about 300 million fresh flowers and 30 million pot plants were sold in Beijing in 2001 (Anonymous, 2003a) via about ten flower markets in Beijing. One of the most important markets is the *Yuquanying Bridge Market* (south-west Beijing). Within a total area of 1 ha, it works both as a retail and whole sale market venue with 200 shops. Flowers, pot plants, garden equipment and seeds can be found. On the market, imported plants from The Netherlands, Denmark and USA are offered, too (Plum, 2001). Another important market is the *Beijing Latai Flower Shopping* mall from the *Beijing Latai Flower & Plant Co., Ltd* (Fig. 3.7B). This company was founded in 1998 and is composed by a flower shopping mall, an auction centre and the *Laitai Flower Street.* The company has multiple services: flower wholesale, flower retail, export-import and a flower auction. In this shopping mall one can buy fresh cut flowers, pot plants, substrates and fertilisers but also artificial flowers, dry flowers and house decoration articles. In the pot plant section, there are many small companies with individual stands. The Dutch *Boerma*

Institute, a technical school for flower arrangements, is also present. The companies pay a rent of € 0.98 m^{-2} day^{-1}. Pot plants from different sizes are also available as well as imported plants. One can find cacti from Brazil, bromelia and callathea from The Netherlands or orchids from Taiwan. In the section with cut-flowers, foliage and flower arrangements it is possible to purchase a large variety of species (e.g. solidago, alstroemeria, gypsophila, chrysanthemum, rose, limonium, matricaria, delphinium, gladiolus, lily, gerbera, hypericum and eucalyptus). Some rose flowers presented visible symptoms of *Botrytis* and the flower buds of some rose cultivars were covered with nets. Cut flowers and cut foliage are mostly coming from the South province of Yunnan.

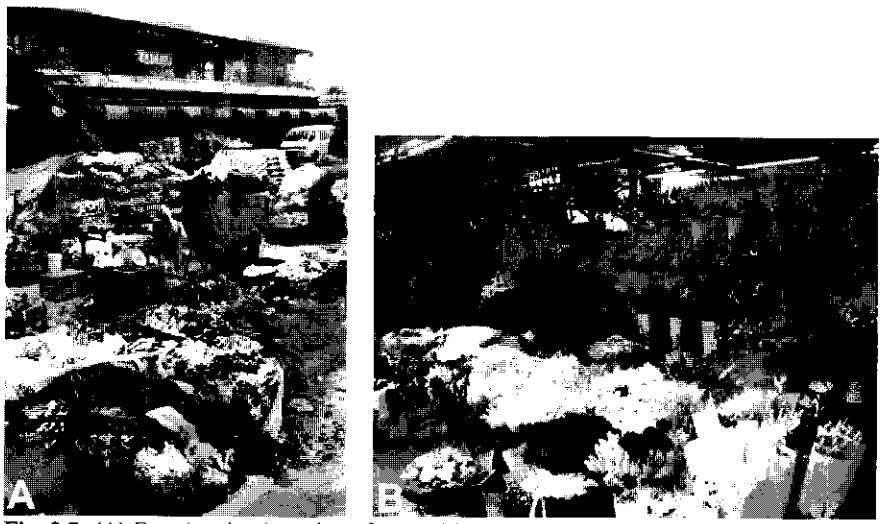

Fig. 3.7: (A) Free (outdoor) market of vegetables and fruits in Beijing and **(B)** indoor flower and pot plants market (*Beijing Latai flower Shopping mall*).

As other Chinese provinces, Beijing has a governmental owned seed market, the *China Beifang Seed Market.* This market serves as a wholesaler (mainly to the Beijing area) and provides seeds from vegetables, flowers and medicinal herbs. The seeds are mainly from Chinese companies but also imported seeds are available. Some Dutch companies have representatives selling their propagation material here. This propagation material includes not only seeds but also young plants (e.g. rose) and bulbs (e.g. gladiolus). The market has three major functions: to regulate and to manage the seed commerce, to provide information on new cultivars and crop management and third to assist the growers. The market aims also to be a communication platform between farmers, companies and the universities. At present and within the 2 ha of the market, it is possible to find about 40 seed companies coming from different parts of China and there is also a public relation office which designs seed-packages. Companies have to pay rent of € 81 m^{-2} $year^{-1}$. The annual turnover of the *China Beifang Seed Market* is € 30 million. This market is planned to expand in a new location with an area of 6-7 ha in the near future. As mentioned in Chapter 2, foreign seeds are much more expensive (e.g. the price for a Dutch tomato seed is 20-30 times higher than for a Chinese one).

3.4 Research, Education and Information sources

One of the most important agricultural research institutions in China is the *Chinese Academy of Agricultural Sciences* (CAAS, www.caas.net.cn). CAAS has been established in 1957 and is a national agricultural research organisation directly affiliated to the Ministry of Agriculture. CAAS is focused on strategic and applied research to solve problems at both national and regional levels. CAAS has a graduate school, five state key crop variety improvement centres and sub-centres and several national and ministerial laboratories and quality supervision and testing centres. CAAS owns about 100 scientific and technology based enterprises and is engaged in science and technology business development.

The Institute of Vegetables and Flowers from CAAS (IVF-CAAS) has two major functions: research and commercialisation of seeds. The crop breeding department of the IVF-CAAS develops research in different areas: 1) *Cruciferae*; 2) *Cucurbitaceae* and 3) *Solanaceae* (tomato, potato). The relevance of potato has increased strongly in the last years, which has a strong consequence to the processing industry. Some cultivars were introduced from The Netherlands and USA. The IVF-CAAS has also an educational/training function. It provides lectures to growers and officials every year and in different parts of China. It also provides technical courses for technicians.

The CAAS also co-operates with the Wageningen University through different types of formal institutional linkages namely the development of a joint Ph.D. training program (educational component), the establishment of a joint plant genome analysis laboratory at CAAS and the use and application of DNA-marker-technologies in plant breeding (www.wucaas.net).

Dutch horticulture and Wageningen are highly esteemed and the wish for co-operation, e.g. regarding greenhouse climate control and structures is strongly present. CAAS has also ongoing co-operation with Japan. The research level at CAAS is among the highest in China but there are still language problems that need to be solved to make communication more efficient.

CAAS (including IVF-CAAS) is crossing a deep reorganisation process that will lead to a significant reduction in the number of employees and less governmental funding. Fortunately, this seems less problematic for IVF-CAAS because it can generate monetary sources by selling seeds via an associated company. To increase the efficiency of the institutes, permanent job positions are already not guaranteed and contracts will be signed on a 3-year basis only.

Currently, research on genetically modified organisms (GMOs) is carried out in IVF-CAAS and other institutes (e.g. in Jiangsu). The perception of GMOs by the Chinese is different from that of the Europeans. GMOs are basically not accepted among Europeans whereas the Chinese consider acceptable the use of GMOs for non-food products (e.g. cotton), but not so for food products. There is some legislation regarding GMO research (e.g. it is necessary to apply for a special permission).

Foreign companies are also supporting research activities. For example the *Pepsico* group supports the reconstruction of buildings of CAAS.

Other important institution in the field of horticulture is the *China Agricultural University* (CAU, www.cau.edu.cn/en/hpen.htm) that resulted from the merge of the former *Beijing Agricultural University* with the *Beijing Agricultural Engineering University* in 1995. The college of Plant Science and Technology is one of the 19 colleges of CAU and it has 3 faculties: Agriculture, horticulture and crop protection. Research on plant breeding is carried out by the College of Biological Science.

Research institutions also can support the activity of modern greenhouse projects. This is for example the case of the co-operation between model villages or demonstration centres and the *Beijing Academy of Agricultural Sciences* (BAAS) regarding crop management, substrate and pesticides. For example, the *Hancunhe Tourism Scenic Village,* received substrates, seeds and pesticides from the BAAS (the latter from the *Institute of Crop Protection* from BAAS).

The visit or active participation of Chinese companies (governmental or private) in specialised horticultural fairs abroad (e.g. the Hortifair in Amsterdam) is another way of gathering information on the latest developments in the greenhouse sector and related markets.

3.5 Politics

The preparation of the Olympic Games in 2008 is at the moment one of the major political priorities of the municipality. Therefore governmental investment in environment and landscaping projects should increase strongly in the coming years due to the needs to build gardens and renovated certain parts of the municipality. It is possible also attending to the water problems of the region in terms of quality and quantity (Wolf et al., 2003) that government will try to guarantee the enforcement of the law regarding a more strict use of fertilisers and pesticides and a more efficient use of water in the municipality.

Chinese authorities are interested in attracting foreign investors in the horticultural sector, but other sectors (e.g. industry) are more important than the horticulture because they can guarantee larger returns for the government.

Regarding external politics, several countries have large representations in China regarding the agricultural sector. One of them is the Netherlands. *The Dutch Ministry of Agriculture, Nature and Food Quality (LNV)* has its largest international agricultural representation in Beijing which reflects the relevance of the Chinese agricultural sector for The Netherlands. That is also partly justified by the close co-operation in different areas namely greenhouse horticulture (e.g. *Sino-Dutch Horticultural Demonstration Centre* in Shanghai) or animal farming and milk production (e.g. *Sino-Dutch Animal Husbandry Training and Demonstration Centre*). A major function of the representatives of the *LNV* at the Dutch Embassy in Beijing is to solve problems related with import-export of goods and support Dutch private investors with information on market trends, laws, politics for different sectors, including horticulture. To accomplish this, it counts with several business support offices (NBSOs) in different parts of China like Kunming, Nanjing or Shanghai.

3.6 SWOT analysis for the greenhouse horticultural sector in Beijing

3.6.1 Strengths

- Large, high income domestic market (market for high quality product)
- Transport infrastructures (roads, airport)
- Know-how to grow pot plants (bromelia)
- More international business environment (many international contacts and more international minded)
- Close location of research centres (CAAS and CAU)

3.6.2 Weaknesses

- Urbanisation pressure
- Higher labour costs compared to other horticultural provinces (e.g. Shandong)
- Lack of know how in crop management (e.g. tomato diseases are one of the big constraints in tomato production (Ma et al., 2000)

3.6.3 Opportunities

- Increasing domestic consumption in pot plants
- Faster rate of modernisation compared to other provinces
- Low production costs (compared to other foreign producing countries)
- Easy contact with foreign markets (Japan, South Korea, Malaysia)
- Increased concern with pesticide residues and demand for higher quality
- High GDP per capita and growth of the tourism activities (hotels and restaurants) will increase the demand for higher quality products (e.g. increase purchase via supermarkets)

3.6.4 Threats

- Lack of good quality water (Wolf et al., 2003)
- Increased production in other provinces
- Oversupply and low prices
- Management (lack of know how, bureaucracy, hierarchical system, limited efficiency of the extension system)

4.

Shanghai municipality

by J. Miguel Costa, Susana M.P. Carvalho and Anke Van der Ploeg

Abstract

Shanghai, like Beijing, is one of the most important consumer centres of vegetables, cut flowers and pot plants in China. The municipality maintains a typical peri-urban horticulture based on open field and greenhouse production of vegetables and ornamentals. In 1999 the total vegetable producing area was estimated at 110,000 ha. The area of ornamentals was less than 2,000 ha in 2001 resulting in a production of about 140 million cut flower stems and 35 million pot plants. The major produced cut flowers are carnation, lily and anthurium. Bromelia, anthurium and poinsettia are the major pot plants. The area of protected cultivation is 2,700 ha of which 2,600 ha is plastic tunnels. The remaining 100 ha have modern greenhouse structures belonging to demonstration centres, research institutes and private owned companies. Vegetables are sold via street markets, whole sale markets and supermarkets. Cut flowers and pot plants are sold via street markets and florists. The market for garden plants is also increasing due to the expansion of the park area of the municipality. Governmental research institutes and demonstration centres, like 'Sino-Dutch Horticultural Training and Demonstration Centre' promote the modernisation of the sector but there is still lack of know-how. The government remains a major investor in the greenhouse horticultural sector but private companies are also investing (e.g. from Taiwan and Hong-Kong). Competition from other provinces will most likely increase for vegetables, cut flowers and garden plants. Pot plant production for internal consumption and export will remain competitive because of the good quality, availability of know-how and availability of greenhouse facilities.

4.1 Introduction

4.1.1 Characterisation of the municipality

Shanghai has 16 million inhabitants and is located in the middle of China's eastern coastline (34°N, 121°E). This municipality covers an area of 6,341 km^2. In the west the neighbouring provinces are Jiangsu and Zhejiang, in the east it faces the East China Sea and in the south the Hangzhou Bay. Except for the southwest corner, Shanghai is a flat area belonging to the alluvial plain of the Yangtze river delta (Fig. 4.1A) and lies on average 4 m above sea level. Lakes and water courses are abundant due to the high ground water level. Shanghai is included in the North Subtropical agricultural climate zone (Chapter 2). Its climate corresponds to the subtropical marine monsoon and has four distinct seasons. The annual average temperature is 15.5°C. January is the coldest month, with an average of 3°C although temperatures can get below 0°C. The highest temperatures (31°C) occur in July and August. The frost-free period is about 230 days and there are 2,014 sun hours per year. The average annual precipitation is 1,200mm of which nearly 60% falls between May and August (Fig. 4.1B). Shanghai can experience torrential rains, reaching up to 50 mm of daily precipitation (Yi-Zhong and Zhanghen, 2000). During the summer the relative humidity is high (83%) while in winter the relative humidity is lower (73%).

Shanghai is the largest economic and industrial centre of China. This municipality has one of the highest GDP per capita of China, € 3994 year, which is more than 5 times the country's average (Royal Netherlands Embassy, 2003). Shanghai's economic structure is rather similar to that of developed countries: the primary (producing) sector accounts only for 2% of the GDP, while the secondary (manufacturing) and the tertiary (services) sectors account for 48% and 50%, respectively (Weimin, 2001).

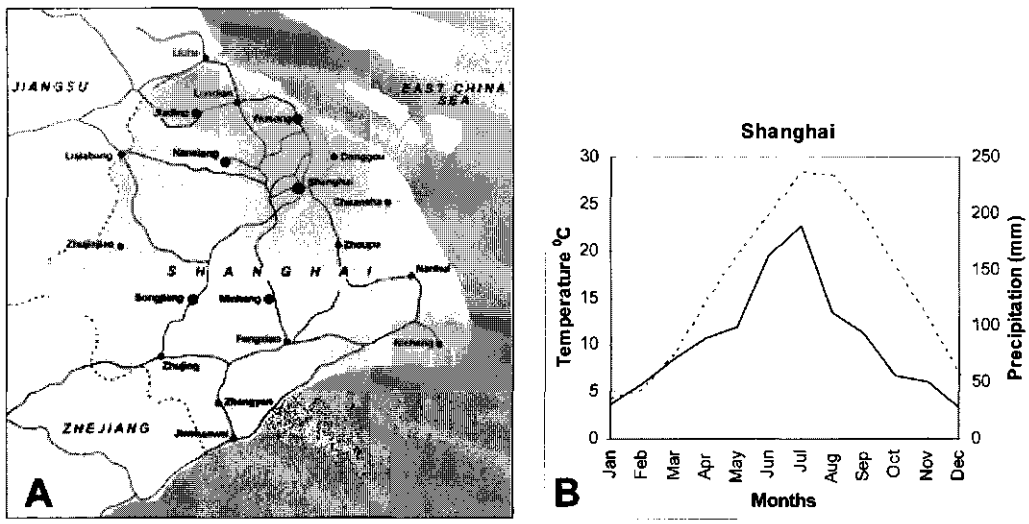

Fig. 4.1: **(A)** Map of the Shanghai municipality (www.maps-of-china.com) and **(B)** average temperature (--------) and precipitation (——) in Shanghai (www.fwcc.org/climate.htm).

4.1.2 Horticultural sector profile

Shanghai, like Beijing, is a good example of an urban agriculture, since the local government maintains about 300,000 ha of land on the edges of the municipality to produce grain and vegetables. The fast and intensive urbanisation caused a clear shift from "intra-urban" to "peri-urban" agriculture (Girardet, 2002). However, to avoid more loss of agricultural land, 80% of the arable land is protected by the Agricultural Protection law (Yi-Zhong and Zhanghen, 2000).

In 1999, the total vegetable production area was estimated to be 110,000 ha (Weimin, 2001). In 2001, the area for cut flower production was 1,334 ha according to the Shanghai Flower Association and the area for pot plant production (including bonsai) was 340 ha (Dutch Horticultural Board-LNV, 2002). Nowadays, the total protected cultivation area in Shanghai is estimated at 2,700 ha. Vegetables are mostly grown under simple plastic greenhouse structures (e.g. polyethylene sheds) and growers are able to produce 3 to 4 successive crops per year (Girardett, 2002). Cut flowers and pot plants are mostly grown in plastic multispan and some glasshouses. Although the area occupied with pot plants and cut flowers is relatively small, the annual production is growing fast. In 2002, 140 million cut flower stems and 35 million pot plants were produced. This represents a 280% increase in the production volume over the last five years (Dutch Horticultural Board-LNV, 2002; Anonymous, 2003). In 2000, the nursery stock sector had an output of 20 million plants (Dutch Horticultural Board-LNV, 2002), which results from the fast expansion of the area of city gardens.

4.2 Production systems

4.2.1 Product diversity and quality

The diversity of vegetables cultivated around Shanghai, either in open field or in plastic tunnels is large. The most important vegetable species grown include several kinds of cabbages, tomato, cucumber, pepper, melons. At this moment sweet pepper is referred to be the most profitable greenhouse vegetable, but because many growers started to produce it, prices are expected to get lower in the near future. Due to the low profitability of vegetable production many vegetable growers are turning to ornamental production. Bromelias, poinsettia and anthurium are among the most important pot plants produced in Shanghai. In the production of annual and perennial ornamental plants, growers choose for a small amount of a big variety of species and colours. For instance, one of the visited companies had about 20 varieties of bromelias and every year three new varieties were introduced into the market. Varieties of bromelias with big leaves are preferred. The favourite colour of these pot plants is bright red. The white colour is not well-accepted because it is associated with sad events.

Shanghai is one of the most important areas for cut flower production (Dutch Horticultural Board-LNV, 2002). Carnation, lily and cut anthurium are among the most important cut flowers. The cut-flower sector faces strong competition from with the Yunnan province and there are problems with excess of production which decrease prices (e.g. gerbera, roses).

For the production of garden plants the main problem is related to the small assortment of species and to a lesser extent their quality (Post and Zhang, 2003). The small diversity was noticed by the relative low number of species, which was repetitively used in the public gardens (namely, cedar, berberis, prunus, poplar, salix, euonymus, azalea, *Thuya orientalis*, buxus).

4.2.2 Production methods, substrates and plant nutrition

Most vegetables are grown in soil (Fig. 4.2A) but the demonstration centres or research institutes are using perlite and stone wool to grow vegetable or flower crops (Fig. 4.2B). It was said that stone wool was easier to manage than perlite but good quality stone wool is more expensive because it has to be imported (see Chapter 2). Furthermore, stone wool has the big disadvantage that it can not be easily recycled. The perlite bags used in greenhouses are often filled on the spot what contributes to the low costs (see Chapter 2). Recycling and deposition of used perlite were also considered to be a problem. In spite of the cultivation in artificial substrates, the yields are still not optimal as compared to The Netherlands. This is a result of a combination of factors: low productive varieties, deficiencies in crop management that would favour flower and fruit abortion, failure in the systems and lack of technical assistance on the imported equipment. Colour plates were also being used in the greenhouses of the demonstration centres.

In a seedling nursery, vegetable seedlings were grown on a mix of vermiculite, peat and perlite on elevated benches. Imported peat was used in the seedling production of flowers and for

propagation of ornamentals by cuttings. In contrast, for vegetable seedlings only local substrates were used due to their low market price. Pot plants like bromelia, poinsettia and anthurium were grown in a mix of peat (imported or local) and perlite, whereas for phalaenopsis production a mix of sphagnum and expanded polystyrene was used. Pot plants were grown on either (simple) elevated benches, concrete floors or gravel covered ground. The substrate used for cut anthurium was foam granules (oasis). The leaves from anthurium plants were periodically removed but contrary to what happens in Europe they were not used as cut-foliage.

Most of the fertilisers used in the production of both vegetables and ornamentals, are made in China but some are imported. In some cases there are problems with the quality (solubility) of the Chinese fertilisers (e.g. K_2S0_4).

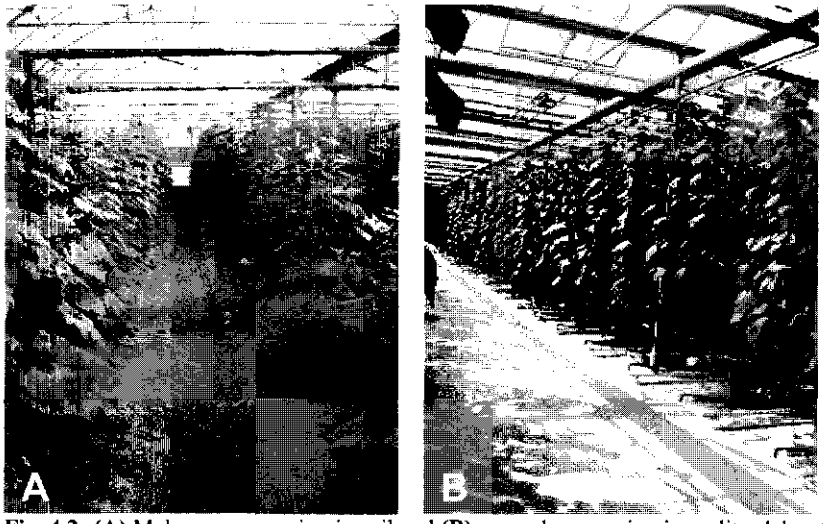

Fig. 4.2: (A) Melon crop growing in soil and **(B)** cucumber growing in perlite slabs at the research station of the Shanghai Academy of Agricultural Sciences.

4.2.3 Starting material and propagation

There are specialized nurseries producing seedlings of both vegetables (e.g. broccoli, cabbages) and ornamental plants (e.g. petunia, begonia, pansy, salvia, snapdragon, primula, vinca). The seeds from the ornamentals are imported from the USA and The Netherlands. In some situations it was possible to see heterogeneous growth of seedlings in part due to irregular covering of the plug trays (Fig. 4.3). In one large company trials with grafting of tomato and watermelon seedlings were conducted. Regarding starting material from ornamentals, unrooted dracaena and yucca plants are imported from Central America and pot phalaenopsis is propagated in vitro. Other ornamental species are propagated by leafy stem cuttings. In this case the propagation procedures still need to be largely improved, especially regarding climate control (light and relative humidity) and the application of rooting hormones.

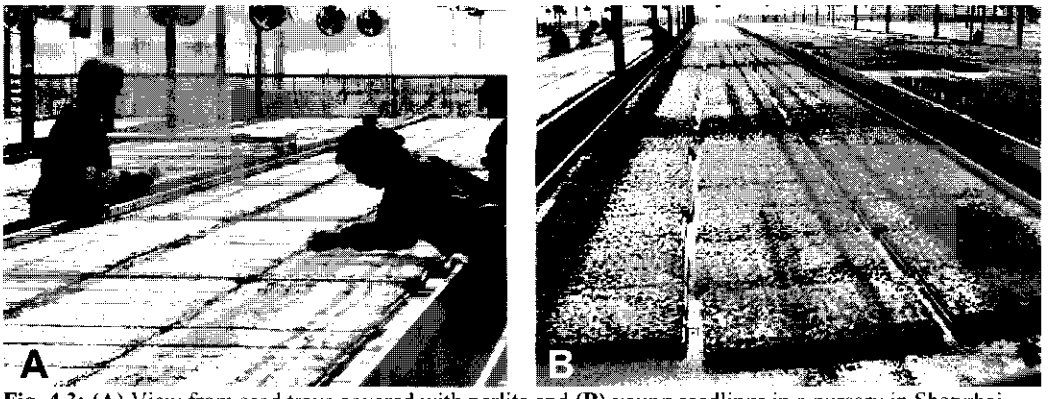

Fig. 4.3: **(A)** View from seed trays covered with perlite and **(B)** young seedlings in a nursery in Shanghai.

4.2.4 Greenhouse structures and equipment

From the 2,700 ha of protected cultivation, plastic tunnels are by far the most important structure used in Shanghai (96% of the total area) due to their low cost per m^2 (Table 1). Tunnels are used to grow both vegetable and flower crops and during the warmer period they are deprived of their plastic cover.

Table 4.1:. Types of structures, total area and costs per m^2 of Chinese manufactured greenhouses in Shanghai.

Structure	Area (ha)	Cost/m^2 (€)
Plastic tunnels (6m span/2.5m high/30m length)	2,500-2,600	2
Multispan (plastic) [a]	60-80	15-23
Glasshouse (Venlo) [b]	30-40	40

[a] including irrigation system
[b] including both irrigation system and computer

Glasshouses are more suitable for winter because they are better isolated, but costs are very high and prohibitive for small farmers. Consequently, only big governmental companies, demonstration centres or research institutes can afford such an investment. Recently a 3 ha glasshouse complex, with a pole height of 5 m, was imported from The Netherlands and built at *"The Shanghai Flower Port"* in Donghai, Pudong (Fig. 4.4A).

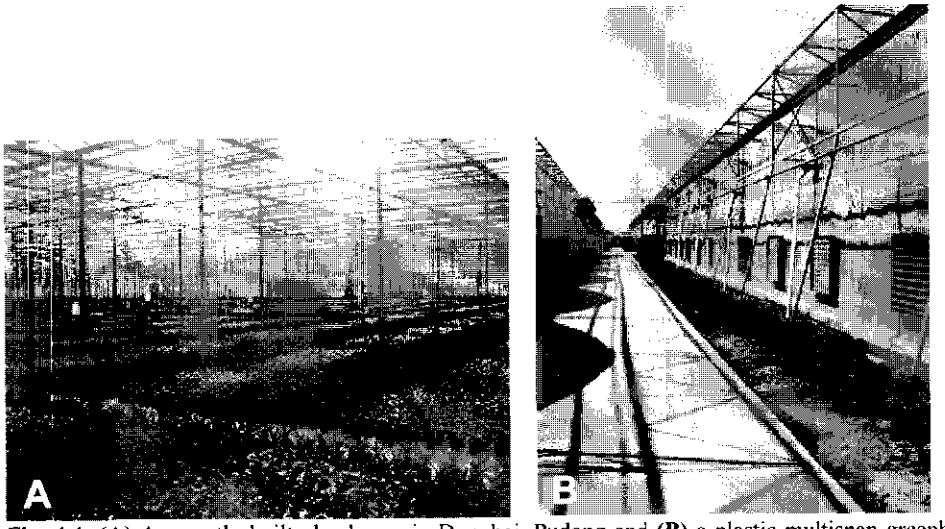

Fig. 4.4: (A) A recently built glasshouse in Donghai, Pudong and **(B)** a plastic multispan greenhouse with pad-and-fan cooling.

Climate control was in general carried out manually although in the most modern commercial greenhouses and research institutes computerised control systems, imported from the Netherlands or Israel, were used. One of the major problems in Shanghai during the summer is the combination of high temperatures (above 30°C) with high relative humidity. In the winter the main problem is the high cost of heating due to low temperatures. Nevertheless, the large majority of the greenhouses have no climate control system. Heating is expensive and market prices of vegetables (and cut flowers) are too low to compensate the use of heating. For cooling in the summer, the more modern greenhouses have installed a pad-and-fan cooling (Fig. 4.4B). In fact, the evaporative system is rather common in China due to its low energy demand (Baomi and Qi, 1999). In order to control high temperatures, the more recent greenhouses have inside and outside shading screens.

Part of the modern greenhouse structures is imported from Italy, France, The Netherlands, Israel or South Korea. The rest is manufactured by Chinese companies. The Shanghai Machinery Institute is one of the local companies designing and building greenhouses structures (multitunnel), each year building 20 ha of greenhouse in this region. It employs about 200 workers and 40 engineers. The production was very manual only with the help of simple and "old-fashioned" technology (Fig. 4.5). The major clients are local governmental companies. The plastic films used for greenhouse covering are also produced in Shanghai.

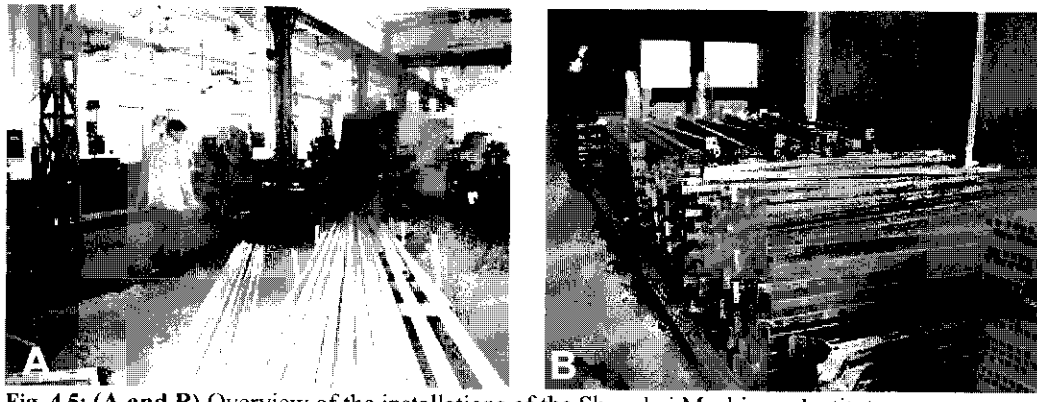

Fig. 4.5: (A and B) Overview of the installations of the Shanghai Machinery Institute.

4.2.5 Water and Environment

In the big greenhouse companies, irrigation water was collected from their own wells (e.g. about 180 m deep). The EC of the water was 1.5 dS m^{-1} and the pH was higher than 8. In some cases, rainwater was collected from the roof and stored in large basins (Fig. 4.6A). Only in extreme cases tap water is used for irrigation purposes, since it increases the production costs and it contains too much chloride. The small farmers often use water from the small lakes or canals, water courses or from smaller wells although this can involve risks as the water can be polluted by organic or agri-chemicals fertilisers. Even the modern greenhouses did not have a closed recirculation system. Furrow irrigation is commonly used in greenhouses whereas fertigation is only used in the more modern greenhouses. Sprinklers were also used in the greenhouses (Fig. 4.6B).

Colour plates were used in the greenhouses of the demonstration centres, but biological control of pests and diseases was not commonly done. Pesticides are mostly bought on the local market, where also most foreign companies are selling their chemicals. These foreign pesticides are more expensive than the pesticides produced by Chinese companies but also more reliable. The used plastic covers from the greenhouses were collected and recycled.

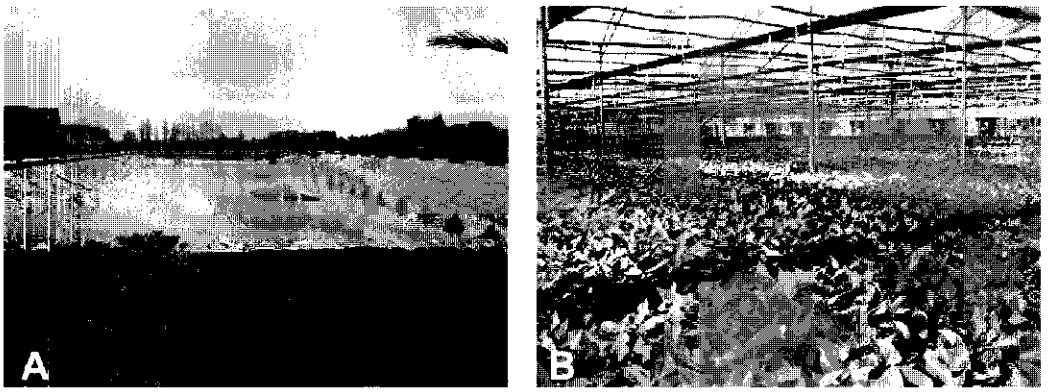

Fig. 4.6: (A) Water basin in a modern greenhouse complex in Shanghai and (B) sprinklers used in the production of pot plants.

4.3 Marketing, Commerce and Logistics

4.3.1 Marketing and commerce

Shanghai is one of the largest and most developed markets for vegetables and ornamentals in China. Vegetable distribution is mainly assured by the activity of about 20 wholesale markets (Yi-Zhong and Zhangen, 2000) and open markets. Supermarkets and hypermarkets are gaining a stronger position in the commerce of vegetables but not all have a perishable section yet (Zhang, 2001). This change has been speeded up by the entry of several European and American supermarket chains in the 90's (see Chapter 2).

Shanghai is a very important consumer of ornamentals due to the high living standards of its population. Yearly 15 million pot plants are sold (Acess Limited, 2002). In the centre of Shanghai, there are street markets where a big assortment of pot plants (e.g. clivia, bromelia), bonsais and garden plants (azalea, camelia, buxus, taxus, japanese acer) are sold (Fig. 4.7). Cut flowers are sold in florist shops, in supermarkets, on the street and even in the metro stations. In 2001, 3,500 million stems of cut flowers were sold (Dutch Horticultural Board-LNV, 2002). There are more than 40 wholesale flower markets in Shanghai. The *Shanghai Jinwen Flower Wholesale Market* is the biggest one with an annual sale of 200 million cut flowers (Dutch Horticultural Board-LNV, 2002). The number of florist shops in Shanghai is estimated at 3,000 (Acess Limited, 2002).

A major characteristic of the pot plant and flower markets is the big oscillation in prices during the year with two major peaks, one at the Spring Festival (Chinese New Year; second half of January or beginning of February) and at the Chinese National Day in October. But more "western" occasions for giving flowers (e.g. Valentines day, Mothers day, Christmas) are increasing in popularity. A pot anthurium may be sold for € 4 just before the Chinese New Year whereas, in the remaining part of the year prices vary between € 0.50 and € 1. The prices of cut flowers like anthurium and gerbera were said to be rather low. Cut-roses were sold for € 0.10-0.20 per bunch of

20 stems. The reason for the low prices of the cut flowers is mainly related to the oversupply, but also due to their lower emotional value as compared with pot plants. Some companies also import pot plant species like yucca and dracaena from Central America and diverse species of cactus (e.g. *Echinocactus grusoni*) from the Canarian Islands (Spain) and Sicily (Italy). Cycas came from other provinces like Guandong or from Taiwan

Shanghai also buys about 70% of its total requirements of tree nursery products (forest, garden and fruit trees) estimated in 10 million plants per year, from neighbouring provinces like Zhejiang and Jiangsu (Post and Zhang, 2003).

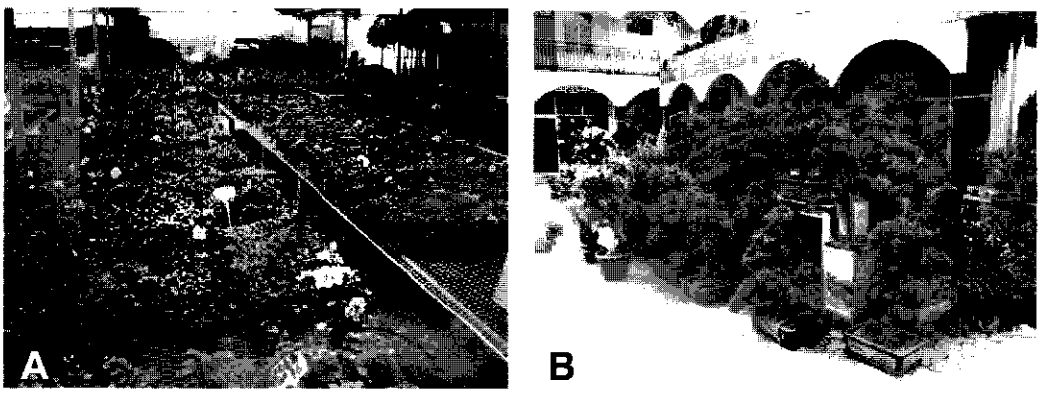

Fig. 4.7: (**A**) Garden centre from the Dan Han Group in Shanghai and (**B**) street market of pot plants and bonsais in the centre of Shanghai

Some of the bigger pot plant producers have their own retail area, where they sell their plants to traders or directly to their costumers. Sometimes they sell also related products like pots, substrates, fertilisers and less related products like garden toys, tools and furniture. Traders are considered to have the highest profits in the chain, taking advantage of a scattered production structure, lack of communication between farmers and from the oversupply of product (both vegetables and flowers). In the 90's when all the products introduced by foreign private companies were innovative, and unique, it was easy to sell them. Nowadays governmental companies are following the example of private companies and thus competition is increased.

Another characteristic of the market is that there is a clear lack of specialisation in both the vegetable and ornamental sector. Companies produce and commercialise a huge range of products to decrease the risk and answer the demand of the market.

4.3.2 Logistics

One of the major constraints in the supply chain of fresh vegetables and cut flowers the deficient cold storage (Chapter 2). Although Shanghai appears to be better equipped than Beijing regarding cold storage facilities and distribution systems (Agrifood-Canada, 2002), water loss, resulting in

wilting, due to bad storage conditions has been indicated to be one of the major causes of total post harvest losses of e.g. pak choi (Acess to Asian Vegetables, 2003). Products are transported to the markets by overloaded open lorries, small vans, motor bikes or tricycles. Shanghai has the advantage of having two international airports, with daily connections to all major cities of China and the world. The recent expansion of the greenhouse production area in Donghai (near the *Shanghai Pudong International Airport*) is also related with the possibility of exporting pot plants.

4.4 Research, Education and Information sources

The *Shanghai JiaoTong University* (SJTU; www.sjtu.edu.cn) is one of the academic institutions providing research and education on greenhouse horticulture. The SJTU was founded in 1896 and has 18,000 students. The School of Agriculture and Biology is one of the 21 Academic Schools and provides a 4-year MSc program in Horticulture. The main horticultural research areas include: crop breeding, protected crop cultivation, crop ecology and physiology, modern seed and seedling technology, storage and processing of horticultural products. The University co-operates with European institutions (e.g. University of Nottingham, England).

The *Shanghai Academy of Agricultural Science* (SAAS[1]; www.saas.sh.cn) is an institute carrying out research on vegetables, ornamental plants and edible fungi. SAAS also works as a demonstration centre and it possesses a greenhouse experimental area with some glasshouses (Venlo-type) but mainly plastic greenhouses. Research is mainly funded by the government although research can be also carried out for private (international) companies but on a small scale. The institute works closely together with the agricultural department of Shanghai Jiao Tong University and provides training for students. Several agricultural demonstration centres were established recently in Shanghai (see Chapter 2). They combine their main function of showing the latest developments in modern greenhouse horticulture with a touristic function for city inhabitants. The *Sino-Dutch Horticultural Training and Demonstration Centre* (SIDHOC; www.nlpekagr.com/frame%20sidhoc.htm) was founded in 1997 and resulted from the co-operation between the Chinese ministry of agriculture and the *Dutch Ministry of Agriculture, Nature and Food Quality* (LNV). SIDHOC's management is under responsibility of the *Shanghai Agricultural Commission* and the LNV. It is financially supported by the LNV and the *Dutch Horticultural Board*. SIDHOC has facilities to offer practical training courses either in open field or in greenhouses (glasshouses, plastic tunnels). All lectures and practical training are given by Dutch teachers and are translated into Chinese. The reason for not having Chinese lectures is that the Chinese consider the foreign teachers more reliable. Dutch companies supply the SIDHOC with horticultural equipment, seeds and young plants. The three main aims of the centre are: 1) To improve quality and quantity of horticultural products: flowers, vegetables, pot plants (production aim); 2) Provide knowledge to improve the use of Dutch high technology for the Chinese horticultural sector (training and demonstration aim); 3) Act as an intermediary between Chinese and Dutch horticultural companies and institutes, directed at generating and exchanging high technology for Chinese agriculture (communication aim). About 10 courses are held twice a year on

different subjects (bulb flower production, vegetable production, pot plant production, greenhouse design, anthurium production, flower arrangements, plant variety protection, etc). A total number of 5,000 trainees participated in the SIDHOC courses between 1998 and 2003. The costs of the courses are € 27.5 per day, which is normally paid by the government or by the companies. In 2004 the LNV will most probably stop financing the centre (Weerdenburg, personal communication). There has been some criticisms about its location in Pudong (Shanghai). For training in cut flowers for example, the centre is too far away from Yunnan, which is the leading producing province of cut flowers (see Chapter 7), and this limits its use on this field. However, the proximity of the new horticultural greenhouse complex (*The Shanghai Flower Port*) which will combine touristic activities with ornamental production, may provide more attendants to future training programs.

4.5 Politics

The local government aims at making Shanghai known as the "City of Gardens" and therefore wants to double the green area per inhabitant in the city. Moreover, all the preparations for the World Expo 2010 will contribute to the expansion of the nursery and gardening sectors in Shanghai. Local authorities are also investing in the pot plant production sector. Evidence of that is the on-going expansion of "*The Shanghai Flower Port*" located in Donghai, Pudong, with 20 ha of modern greenhouses (imported or built in China) for pot plant production (bromelias, phalaenopsis, anthurium).

Shanghai is free market oriented and open to the west. This explains why Shanghai is normally chosen by foreign companies for product presentations and technology demonstrations and therefore, can be seen as the best gateway to enter the Chinese market. It also explains, that there is a high number (about 80) of foreign investors and joint venture flower companies with partners, primarily from The Netherlands but also from USA, Japan, Hong-Kong and Taiwan (Anonymous, 2003). Investors from Taiwan and Hong-Kong are very important and successful not only because they enjoy special tax advantages but also because they know better the Chinese language and culture, which facilitates the co-operation with the Chinese mainland partners.

Even that the softening of the politics has occurred (that is why we were able to visit most of what we wanted to visit), the majority of the companies is still governmental owned. Thus, the government still maintains a strong control on the different fields of the horticultural sector: from production till the consumer, on the imports and on the research. For instance, the import of certain products like fertilisers or pesticides is still tightly controlled by import quotas imposed by the government.

To promote the expansion of greenhouse cultivation in the municipality the government provides both greenhouse structure and the necessary infrastructures for the production (water systems, roads, electricity). Private companies (Chinese or foreign) can rent the land area with the greenhouse structure for a certain period of time (8-10 year contracts). Both private and governmental companies are trying to invest in different sectors to spread the risk and catch the

profits from the fast growing sectors. One example of this is the Dan Han group that produces pot plants and garden plants but also sells gardening material, imported substrates, fertiliser, etc.

4.6 SWOT analysis for the greenhouse horticultural sector in Shanghai

4.6.1 Strengths

- Good transport infrastructures (good roads, harbour, airport) (much better than other provinces; Shanghai has the largest harbour of China)
- Large domestic market, better educated consumers and elite market
- High quality of pot plant production (e.g. bromelia)
- Know how available (more technicians, sources of information and mechanisation available comparatively with other provinces)

4.6.2 Weaknesses

- Urbanisation pressure
- Higher labour costs compared to Shandong and Yunnan
- Weather conditions for cut flowers (high temperatures and high relative humidity in summer) not so good as in Yunnan
- High competition among new companies

4.6.3 Opportunities

- Increasing domestic consumption in pot plants (internal market)
- Low production costs (compared to foreign producers) (export market)
- Easy contact with the foreign markets (Japan, Hong Kong, Taiwan) (export market)
- Increased concern with pesticide residues and demand for higher quality
- High GDP per capita and growth of the hotel and restaurants sector will increase demand for higher quality products

4.6.4 Threats

- Increased production in other provinces
- Greenhouse vegetables can be produced cheaper elsewhere
- Oversupply and low prices
- Increased production costs (e.g. labour)

5.

Jiangsu province

By Susana M.P. Carvalho and Ep Heuvelink

Abstract

Jiangsu is the second largest Chinese provincial economy, after Guangdong, and it has one of the highest population densities of China. This is both a strength (large local market) and a threat (pressure on the land for construction and industry). Like the agrochemical sector, also horticulture prospered greatly in recent years and has become one of the best performing agricultural sectors in the province. Jiangsu is the main producer of ornamentals in China, covering an area of 17,600 ha in 2000. In 2003, the vegetable production occupied an area of about 1.34 million ha, of which 21% was protected cultivation. Solar greenhouses and plastic tunnels are by far the most used structures. The number of high-tech greenhouses is low and restricted to demonstration centres and education or research institutions. Both small farms and large modern companies are usually not specialised, which is a strategy to decrease the risk by increasing product assortment. Product quality varied strongly according to the type of product, with a top quality generally reached in Bonsai and anthurium production. The production of ornamental trees and pot plants is expected to increase since many companies are at least partly moving from vegetable to ornamental production. Despite competition from Shandong, greenhouse vegetable production will remain important due to the large provincial market and the available experience and know-how. The lack of know-how on crop management and pest and disease control and the poor post-harvest handling of vegetables are major weaknesses of the horticultural sector. The direct influence of government in the management of 'private' companies, the limited availability of good water and land and competition with Shandong province for vegetable production are threats for greenhouse horticulture in Jiangsu.

5.1 Introduction

5.1.1 Characterisation of the municipality

The Jiangsu province lies on the eastern coast of China and it occupies the southern part of the North China (30-35°N and 116-122°E). It has borders with Shanghai municipality in the south-east, with Shandong in the north and Anhui in the east (Fig. 5.1A). Jiangsu covers an area of more than 100,000 km^2 and has around 74 million inhabitants, resulting in 740 inhabitants per km^2. It is therefore one of the most densely populated provinces of China (Jiangsu Agriculture Government, 2003; Southeast University, 2003).

Jiangsu's topography is characterised by plains, with the majority of the area located at less than 50 meters above sea level. Hilly land occupies only 5% of the total provincial area. Most parts of the plain are formed by the deposition of the Yangtze River. This province is situated in the warm temperate and subtropical agricultural climate zones (Chapter 2), with a humid and semi-humid monsoon climate. Jiangsu has an annual average temperature of 13-16°C (-2 to -4°C in January; 26 to 29°C in July), a frost-free period of 200-240 days and 2000-2600h of sunshine per year. The annual precipitation varies from 800 mm in the north-western region up to 1200 mm in the south-eastern region, with 50% of the precipitation occurring in the summer. Hurricanes often hit this province at the end of summer and the beginning of autumn (Southeast University, 2003). In Nanjing, the provincial capital, the average monthly relative humidity varies between 74 and 82%. The highest temperatures occur in summer, which coincides with the period of the highest precipitation (Fig. 5.1B).

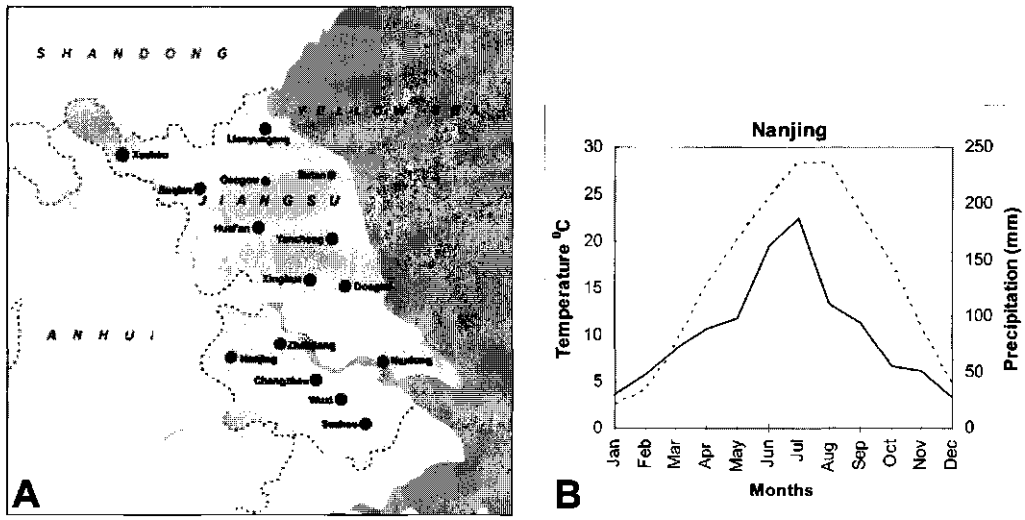

Fig. 5.1: **(A)** Map of Jiangsu province (www.maps-of-china.com) and **(B)** average temperature (----) and precipitation (—) in Nanjing city (B) (www.fwcc.org/climate.htm).

Jiangsu is the second largest provincial economy in China (after Guangdong province), with a total GDP of € 104.5 billion in 2002, an increase of 11.6% compared to 2001 (Consulate General of Switzerland, 2003). In the same year, the GDP per capita ranked the fifth position in China, and was 90% higher than the national average (US Commercial Service, 2003).

5.1.2 Horticultural sector profile

Horticulture has become one of the agricultural sectors with the best performance in Jiangsu province. The area of vegetable crops has increased dramatically in recent years. In 1999 it was about 930,000 ha, whereas in 2003 this area had increased to about 1.34 million ha, of which 278,000 ha was protected cultivation (Luo, pers. comm.). Comparatively to the vegetables, the area occupied by ornamentals is relatively small, only 17,600 ha in 2000. In 1999 this was about 14,000 ha, of which 300 ha in modern greenhouses. This area makes Jiangsu the province with the largest area dedicated to ornamental production. The most important ornamentals produced are by far the ornamental trees (14,000 ha) followed by pot plants (2,568 ha). Cut flower production occupied only 545 ha in 2000 (Dutch Horticultural Board-LNV, 2002). Jiangsu produced in 2001 a total of 80 million pot plants, 600,000 pots of bonsai and 100 million of cut flowers' stems (Jiangsu Agriculture Government, 2003).

The greenhouse horticulture production sector can be divided in two contrasting groups: the small-scale family farms and the large governmental or semi-governmental companies. The first group, and by far the biggest, usually uses simple solar greenhouses or plastic tunnels, which have been 'given' by the government to each family. In general, each family has one or two solar greenhouses (around 350 m^2 each) that are concentrated in a certain location. For instance, in the suburbia of the Huian city an extensive area of solar greenhouses can be found and some of them were build around 20 years ago (Fig. 5.2). The large governmental or semi-governmental companies, so called '*Modern Horticultural Centres*', frequently have high-tech glasshouses and work both as demonstration farms and also produce and sell vegetables or ornamentals. Most of these centres are governmental owned but privately run. Only very few 'real' private horticultural companies, i.e. completely independent of governmental investment/interference are located in this province. In the small farms only family labour is used, whereas in the large companies both permanent and temporary staff are employed. The 'demonstration centres' usually employ a rather high number of technicians and local farmers are hired during the production peaks, which represents an additional source of income for them. In 2001, the average net income in Jiangsu was € 373 per rural inhabitant per year (Jiangsu Agriculture Government, 2003). There is a clear lack of specialisation in the horticultural sector, which was observed in both the small farms and the large companies. The demonstration centres for example have multiple functions. They can provide greenhouse facilities for research (e.g. for the Nanjing University), receive visitors (agro-tourism function) and commercialise the horticultural products (produced in the centre or from other growers).

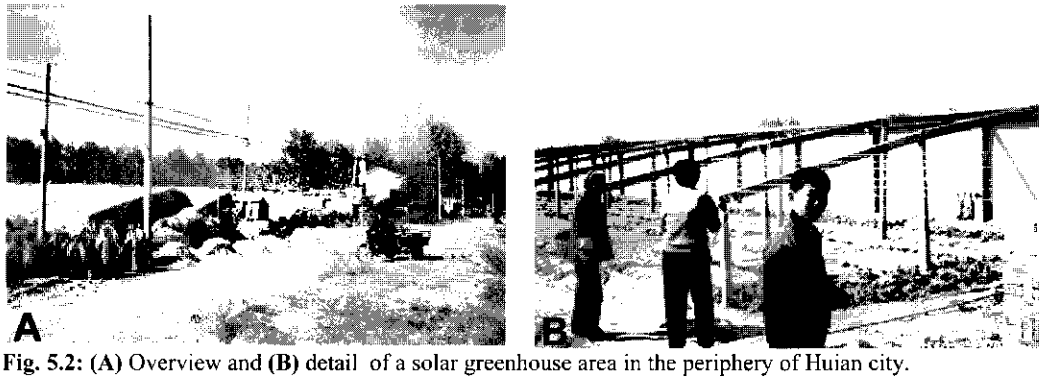

Fig. 5.2: **(A)** Overview and **(B)** detail of a solar greenhouse area in the periphery of Huian city.

5.2 Production systems

5.2.1 Product diversity and quality

Jiangsu province produces a great variety of horticultural products. To reduce the risk growers often produce a wide assortment of species and cultivars. This is especially the case of the modern companies producing pot plants, where large product diversity can be found (e.g. azalea, poinsettia, cyclamen and anthurium). Colour is a very important issue when selecting new cultivars of vegetables and ornamentals. For instance, sweet pepper cultivars with orange or green colour were told to be less profitable than red and yellow ones. Red is also the favourite colour for both pot plants and cut flowers, followed by pink. Shiny leaves and big flowers are as well important quality aspects in ornamental production. For cucumber fruits the size is an important quality attribute and the market prefers the small ones. In the last years, the market share of special vegetables, fashionable fruits and ornamental plants is considerably increasing (Jiangsu Agriculture Government, 2003). Hence, the production of some of these special products became very profitable, which is the case of edible fungi and *Artemisia selengensis* (vegetable).

In general, the product quality is very much dependent on the kind of product, production system and on its final destination (i.e. local market or export). A high standing quality was frequently obtained in cut and potted anthurium as well as in the bonsai production. Cut anthurium was often packed individually, using a plastic bag to protect the flower, and each stem was inserted into a 'plastic tube' filled with water but no preservatives were added. The quality of other pot plants was often lower (e.g. cyclamen and azalea with irregular plant size, *botrytis* problems and irregular irrigation) even when produced by the same company. This may be due to the fact that anthurium is considered a high value product and, therefore, buyers demand higher quality. Another reason can be the lack of know-how on the production techniques, possibly derived from the lack of product specialisation. Vegetable growers producing in modern greenhouses referred that their products could compete with the open field production due to the higher quality, which resulted in a

better price (e.g. up to 50% higher price for cucumbers). It seemed to us that horticultural products that were produced for export to Europe (e.g. vegetables for processing industry) or to other Asian countries like Japan (e.g. carnations, *Artemisia selengensis* etc) had usually good quality. Furthermore, growers seem to be specialised for supplying the local market or for exporting their products, although the exporting companies also sell their low quality products on the local market.

Pest and diseases were not considered as a big problem by the growers. Nevertheless, we observed several times the occurrence of problems such as *botrytis* (e.g. in cyclamen), mosaic virus, white fly and leaf miner (e.g. tomato). In some cases the growers were not able to identify the observed pest or disease, but according to them this did not cause high losses in yield. According to the governmental sources Jiangsu has issued a series of provincial codes for food safety, environment of origin and technical standardisation. A number of provincial and municipal pilot production bases have been built to the food safety standards (Jiangsu Agriculture Government, 2003). At the *Baiyunting Vegetable Market* (Nanjing) products are randomly analysed for pesticides' residue. Also a vegetable processing company located in Nanjing conducts quality control of the products at the grower level and has a laboratory for pesticide testing.

5.2.2 Production methods

The small-scale farmers mainly grow vegetables in soil beds. These beds are normally covered with plastic film (mulching) to reduce evaporation, increase soil temperature and reduce the growth of weeds. Edible fungi can be produced in solar greenhouses that are kept in dark conditions by covering the greenhouse with a straw mat.

In the large horticultural companies that use multi-tunnel greenhouses, vegetables are also often grown in soil. Occasionally some fruit vegetables like tomato, sweet pepper or cucumber are grown in substrate, but this only happens in high-tech glasshouses (Fig. 5.3). However, even in the most sophisticated glasshouses, the yield is much lower than the one obtained in The Netherlands. For example, the yield of truss tomato varies between 28 and 35 kg m-2 year-1 (for three crops per year), whereas in The Netherlands productivity is around 55 kg m-2 year-1. In the modern greenhouses, cucumber is always produced using the 'high wire system' and 30 kg m-2 year-1 was mentioned to be a common yield, which contrasts with 85 to 90 kg m-2 from The Netherlands. A possible reason for such low annual yields, despite the higher light conditions (more 500-1000 hours of sun than in The Netherlands), can be related to the lower plant density (to promote air circulation and reduce problems with high humidity) and to the higher temperatures during summer as compared with The Netherlands. These high temperatures result in poor fruit set in cucumber and sweet pepper. In spite of these limitations, many improvements could be made on the crop management to increase yield and product quality. For instance, cucumber plants are often grown with too many fruits per node leading to a high rate of fruit abortion.

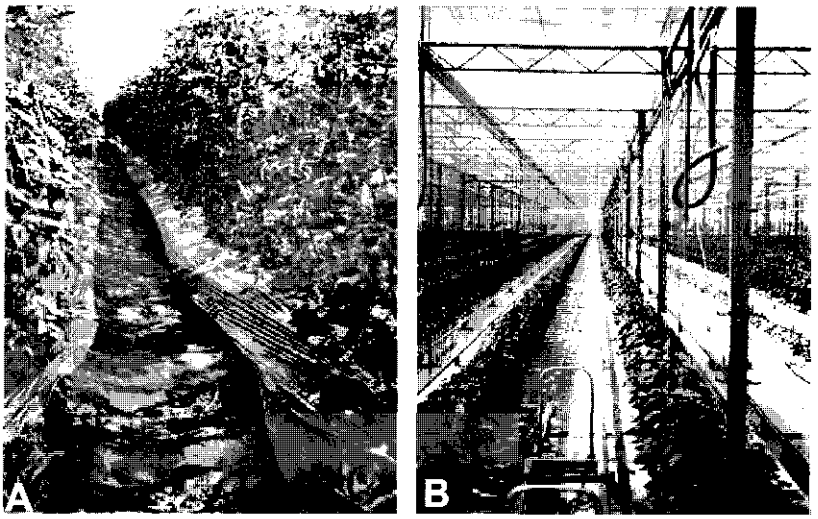

Fig. 5.3: Example of two large horticultural companies: **(A)** tomato production in soil in a multi-tunnel greenhouse; **(B)** soilless sweet pepper production in a high-tech venlo type glasshouse.

Except from cut anthurium, which was always grown in soilless culture, the other cut flowers are normally grown in soil (e.g. gerbera and carnation). Pot plants are often placed on top of an anti-rooting canvas, which is covering the soil (e.g. azalea and salvia), but also movable benches are used in some crops (cyclamen, poinsettia and propagation of nursery stock).

5.2.3 Starting material and propagation

In general, there are no specialised vegetable nurseries for production of young plants in Jiangsu. We visited one company located in Wuxi that started its activity with seedling vegetable production but now is gradually shifting towards production of ornamental plants due to a lack of clients. The seeds used are mainly from Chinese varieties because these are cheaper. These varieties are supplied by local governmental companies or institutes, which develop their own breeds (e.g. Jiangsu Academy of Agricultural Science, JAAS). Imported varieties of vegetables are used in some demonstration centres (e.g. tomato and sweet pepper) and the name of the breeding companies is advertised in posters hanging next to the crops. In the pot plant sector, companies use to import young plants (e.g. azaleas from Belgium; phalaenopsis from Taiwan) and grow them mainly for specific celebrations (e.g. New Year). Propagation by tissue culture is done for phalaenopsis in one 'demonstration centre'.

5.2.4 Greenhouse structures and equipment

Plastic tunnels and solar greenhouses are the most frequently used structures in protected cultivation in the Jiangsu province. Different kinds of solar greenhouses exist, from rather simple structures with mud walls and bamboo frame to more sophisticated ones with brick walls and concrete pillars

(Fig. 5.4B). The cost varied greatly among them, with a top solar greenhouse of about 700 m^2 costing around € 1380, which is double the price of the more simple ones. The 'Modern Horticultural Centres' had modern plastic multispan greenhouses and/or Venlo-type glasshouses. Although some of these structures were imported from abroad, nowadays the Chinese greenhouse builders are able to build them using local materials (e.g. plastic, glass and aluminium). We have visited several Chinese Venlo-type greenhouses that were very similar to the Dutch ones. Nevertheless, the Chinese greenhouse manufacturers are still not able to produce certain components, namely climate control systems and some engines (e.g. for control of screen opening). Therefore, these components still have to be imported from countries like The Netherlands or Israel. Some growers and institutes stated their preference for the Israeli's climate control software because its interface is translated into Chinese. Furthermore, some growers complained that Dutch companies have supplied them with the climate control but not much further technical support has been given to them. Heating systems (e.g. hot air or hot water heating pipes) and active ventilation systems (pad-and-fan) are frequently present in modern greenhouses. However, most of the times ventilation is still done manually (Fig. 5.4A). In addition, the modern greenhouses are often equipped with external shade screens to reduce greenhouse air temperature. In solar greenhouses straw mats are used as efficient energy saving screens (Fig. 5.4B).

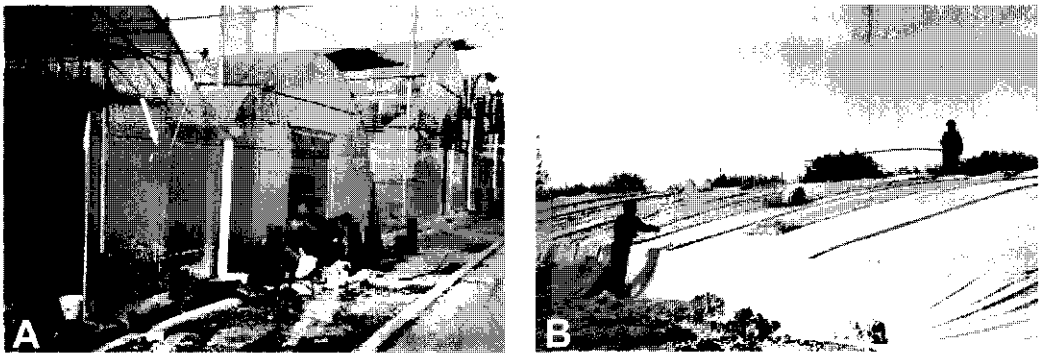

Fig. 5.4: Manual ventilation (see arrow) and use of external screens both in multi-tunnel greenhouses (**A**, shade screen) and in solar greenhouses (**B**, energy saving screen made of straw).

5.2.5 Substrates and plant nutrition

As previously mentioned both vegetables and ornamentals are mostly grown in soil and the substrates used in soilless cultivation are to a big extent produced in China. In the soilless cultivation of vegetables in the Jiangsu province, several substrates are used namely a mix of perlite with peat (e.g. tomato) or perlite mixed with vermiculite (e.g. cucumber). Trials with stone-wool have been conducted with tomato and sweet pepper at a 'Modern Horticultural Centre' and at JAAS. In JAAS, yield levels on stone-wool are being compared with composted Chinese medicinal

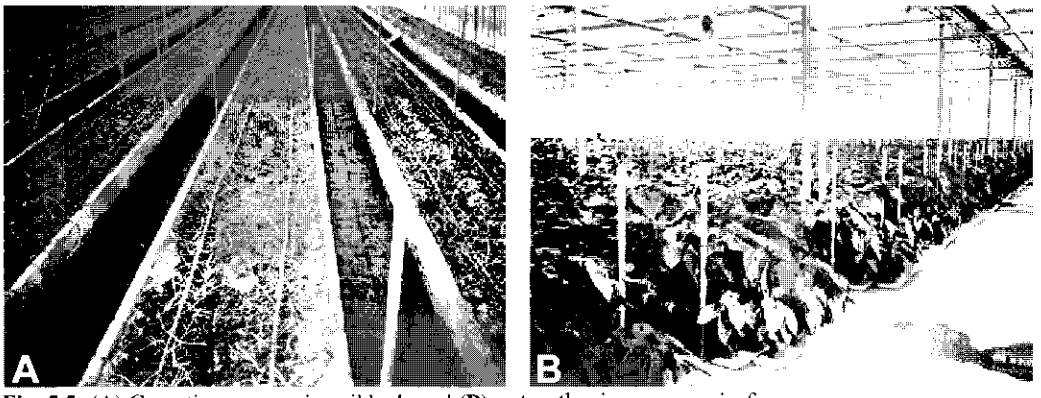

Fig. 5.5: (A) Carnations grown in soil beds and **(B)** cut anthurium grown in foam.

herbs as a substrate. In general, stone-wool has a low acceptance due to its high price as compared with other substrates, even when produced in China which costs only 25% of the imported stone-wool. In the edible fungus production saw dust is mixed with cotton waste in 1 kg bags.

Pot plants are usually grown in local soil (not always the most appropriate one, e.g. clay soil used in azalea and ornamental cabbage) or in a mix of peat and perlite (e.g. poinsettia, cyclamen). A mix of Chinese medicinal herbs with perlite is also used in poinsettia production. Phalaenopsis produced in a demonstration centre were growing in sphagnum. Cut anthurium is always grown in foam (oasis) and carnations are usually grown in soil beds using a mix of peat and local soil (1:1) (Fig. 5.5). For production of nursery stock, several combinations of different substrates are tested to find out the best combination (for example soil mixed with perlite, composted Chinese medicinal herbs or vermiculite).

Jiangsu is one of the principal agrochemical producers in China, representing 25% of the total Chinese agrochemical production. Jiangsu has 220 agrochemical plants and produces 90 million kg of active ingredients (Jiangsu Agriculture Government, 2003). In 2002, Jiangsu produced about 6% of the China's total NPK production (Gulobkov, 2003). Therefore, most of the used fertilisers are locally available in the province.

5.2.6 Water and environment

Water availability is not considered to be a problem in Jiangsu province. There are three large water systems: the Yangtze River, the Huaihe River and the Shuhe River, all flowing from west to east. The Great Canal flowing north to south links up various rives, canals and lakes, resulting in a complex network with the inland waterways extending in all directions (Southeast University, 2003). By the end of 2001, effective irrigation covered 3.9 million ha of arable land, including 3.7 million ha equipped with diesel or electrical pumps. These irrigation facilities have secured the crop harvest of 3.1 million ha. To support crop production, about 460,000 tube wells are available throughout the province (Jiangsu Agriculture Government, 2003). In the visited solar greenhouse

area, near Huian city, each farmer has a well of 5 to 6 m deep (costing around € 10 per well) to extract underground water. On several nurseries of ornamental trees, water from the river was used for irrigation. In the modern greenhouses, irrigation water is normally collected from the roof (rainwater, EC = 0.2-0.3 dS m-1) and stored in water basins (Fig. 5.6A). The water basins' capacity ranges from 700 to 5500 m3 and their surface is never covered. In the small farms plants are usually watered by hand or by furrow irrigation (Fig. 5.6B). Hand irrigation is also used in some big companies, but most of the high-tech greenhouses have drip irrigation systems to increase water use efficiency and guarantee a more homogeneous irrigation.

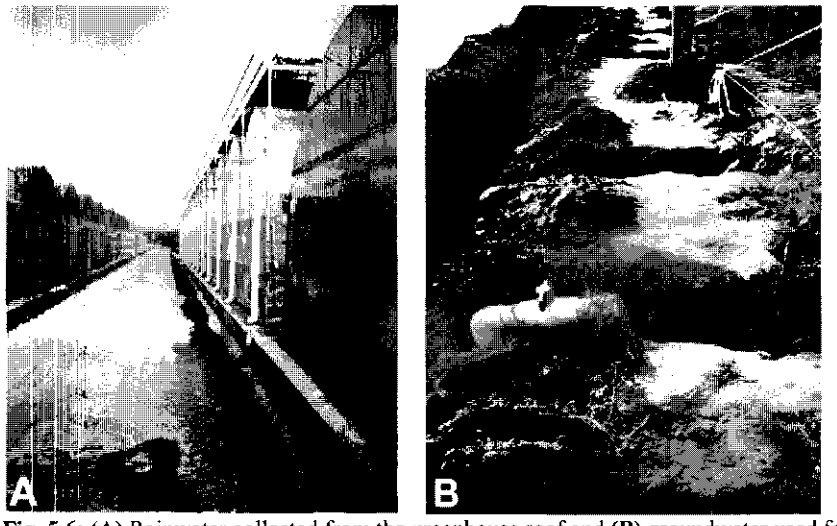

Fig. 5.6: (A) Rainwater collected from the greenhouse roof and **(B)** groundwater used for furrow irrigation .

Most growers have very little environmental awareness. For instance, chemicals are applied to the crops on a regular basis and the nutrient solution is never recycled in the soilless cultures. There is hardly any biological control, except from the colour plates used against some pests that were seen in one modern company. One big tomato grower stated that no bumble bees were used for pollination since their price is higher than the labour costs for the application of hormones to the flowers. In spite being highly polluting coal is still by far the most important source of energy used in the protected cultivation. In a modern greenhouse for cut anthurium and vegetables production, steam was transported from a neighbouring steam factory (energy source: coal) and was further used for heating the water (Fig. 5.7).

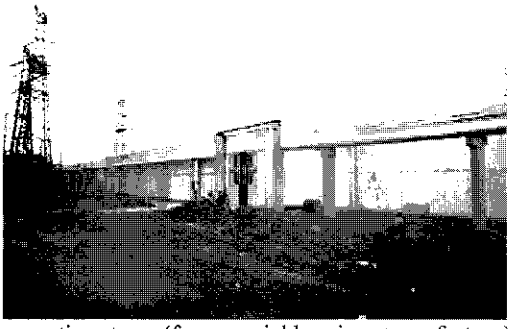

Fig. 5.7: Pipe system for transporting steam (from a neighbouring steam factory) to be further used to heat a cut anthurium and vegetable glasshouse.

5.3 Marketing, commerce and logistics

5.3.1 Marketing

Various types of rural co-operatives and associations are among the fast-growing rural intermediaries in close bondage to farmers, providing extensive services and having the farmers better organised for marketing (Jiangsu Agriculture Government, 2003). Wholesale markets, specialised markets, general markets and consumer markets are on the rise in the Jiangsu province. Wholesale markets are the main places for vegetable exchange. There are several retail markets spread throughout the Nanjing area, including indoor and open-air markets. It is through these retail markets that 90% of the vegetables are sold to the consumers in Nanjing city (Lu, 2003). After the international foreign-owned supermarket chains started their business in China, supermarkets became the new vegetable distribution outlets in Nanjing. Supermarkets have a good image for one-stop shopping and for good quality vegetables. Furthermore, they have an important role in the introduction of relatively new and luxury vegetable varieties with added value (e.g. pre-packed and minimal-processed vegetables). Nevertheless, the consumers see them as more expensive than other vegetable outlets like the street markets. Our group visited one retail flower market (Flower West Market) and one wholesale vegetable market (Baiyunting Vegetable Market) both located in Nanjing city.

The *Flower West Market* (Fig. 5.8A) was initiated in 2001 and it occupies an area of 1 ha of which 0.7 ha is covered with buildings. The total number of sellers is around 90, and they pay a rent of about € 2 per m^2 per month. Both traders (middle men) and growers are selling in this market and have a fixed stall. Customers are local flower shops, hotels and private consumers. Almost all products are from Chinese origin, except for some imported bulbs and young plants of cyclamen and anthurium. This market has an estimated annual turnover of around € 2 millions.

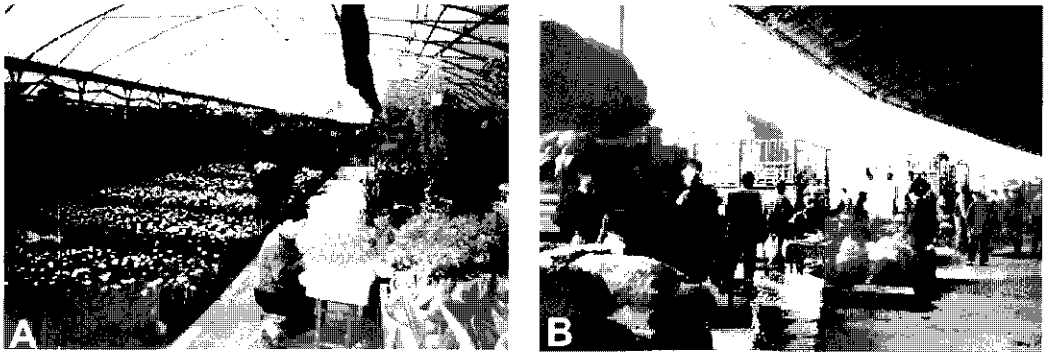

Fig. 5.8: Details of two wholesale markets located in Nanjing city: **(A)** Flower West Market; **(B)** *Baiyunting Vegetable Market.*

The *Baiyunting Vegetable Market* (Fig. 5.8B) started in 1986 and it is the largest vegetable wholesale market in Jiangsu. This market is open 24 h per day and it covers a total area of 5 ha, of which 2 ha is indoor. The number of sellers is 300 to 400 and they have no fixed stalls to sell their products. Sellers are almost all traders and only 5% are producers themselves. Transactions have to be registered at special 'desks', distributed over the market, and a buyer can only leave the market when he can show such registration bill. The wholesale market charges 2.5% on each transaction, which also enables the market managers to have a good inside into the market turnover. Each day about 2.5 million kg of vegetables are sold, which resulted in a total turnover of € 216 millions in 2002. Customers are retailers, hotels and universities but private consumers cannot buy in this market. This measure is ensured by minimum transaction amounts of 40-50 kg. Besides fresh vegetables, also dried vegetables, mushrooms and spices are sold in *Baiyunting Vegetable Market.* Here the sellers have permanent places. This part of the market is open from 7 am till 7 pm and private consumers can buy there.

5.3.2 Commerce

Jiangsu is among the five most important provinces for vegetable export (Lu, 2003), supplying nearly half of the amount of Japanese vegetable's import from China (Jiangsu Statistical Year Book, 2002). However, most producers still lack market information (e.g. on the quality standards and delivery requirements of the supermarket chains) which gives them less negotiation power and lower prices. Though, this seems to be changing since several big western-style glasshouse producers already have contracts with local supermarkets for direct sales. The amount of consumers that prefer to purchase their vegetables through supermarkets is also increasing, although at present their market share is only 5% of total vegetable purchases. This share is expected to rise to 50% in the next 5-7 years, to reach an equal share as in other Asian cities like Bangkok and Kathmandu (Lu, 2003).

High transport costs and considerable product losses make current margins for vegetable sales extremely low. Supermarkets, processing companies and export traders tend to establish preferred-supplier relationships in order to increase certainty on product characteristics and to reduce monitoring costs. Supermarkets have the power to exert pressure to the producers to ensure the vegetable quality meets their requirements. However, at present the power in the market is with traders: they are the essential link in most of the vegetable chains and have most market information. Supermarkets could take over this power, like in Europe, however, at present supermarkets are still a small player in the market (Lu, 2003).

In the ornamental sector, traders come to the large companies producing pot plants and/or cut flowers, to choose the products. For this reason these companies like to have a kind of show room, with a large product assortment, where they can take their visitors.

5.3.3 Logistics

Although the wholesale markets for vegetables look at first sight very chaotic and not well organised, they seem to function well. Trucks come in the wholesale markets fully packed and will sell from where there is place available. For instance, at the *Baiyunting Vegetable Market* when a certain seller has a good spot and his truck is almost empty, he phones to his co-workers so that the new truck can take the same spot. Local distribution is often done with transport bicycles (Fig. 5.9A) and vegetables are further sold in many places on the streets close to where consumers are (e.g. gates of the universities). Traders (middle men) are an important link in the vegetable supply in the Nanjing area. They buy vegetables at wholesale markets or at individual growers and sell on retailer markets, supermarkets or to institute's canteens. The main limitation in the supply chain of vegetables is the handling of the product: hardly any cold stores and cooled transport exist and the packaging is poor resulting in product damage. As mentioned in section 5.2.1 more attention is usually paid in the handling of cut flowers and ornamental plants (Fig. 5.9).

Jiangsu, as one of China's most developed provinces, possesses a large communication network. Highway communication has developed very quickly, especially in the North of the province. Recently, a highway was finished connecting Nanjing to Shanghai with a second Yangzhe river bridge near Nanjing. Railway communication is also good, since the connections between Beijing-Shanghai, Lanzhou-Lianyungang and Nanjing-Tongling all pass through Nanjing or Xuzhou or both. In addition, waterway transportation is very convenient for some type of cargo (Southeast University, 2003). This is the case of processed vegetables and fruits, which are exported to Europe and transported by vessel at –18 °C.

Fig. 5.9: Contrasting product handling: **(A)** vegetables poorly packed and transported; **(B)** cut anthurium carefully packed.

5.4 Research, education and information sources

5.4.1 Research and education

Jiangsu province has several universities and institutes providing agricultural education and research. The *Nanjing Agricultural University* (NAU), *Yangzhou University* (YZU), *Nanjing Forestry University, Jiangsu Polytechnical Institute of Agriculture, Jiangsu Technical Institute of Agriculture and Forestry* are some of the education and research institutions. Research is also conducted at several institutes such as: *Jiangsu Academy of Agricultural Science* (JAAS), Nanjing Institute of Soil Science, Nanjing Institute of Botany and Jiangsu Academy of Forestry Science (Jiangsu Agriculture Government, 2003). Our group had the opportunity to visit the Agricultural College of NAU and YZU as well as the experimental greenhouses from JAAS.

The Nanjing Agricultural University (NAU, www.njau.edu.cn) is one of the earliest higher education establishments for agriculture. This university enjoys a good reputation in China and abroad on the field of agricultural sciences. Besides agriculture, the education structure of the university also includes engineering, economics, science and arts. The present number of students is larger than 7000, including about 750 doctorate and postgraduate students. NAU pays great attention to its international collaborations and exchanges. It has established co-operation agreements with more than 20 institutions in 10 different countries including The Netherlands. We were received at the College of Agriculture, which has a research focus on crop growth modelling and greenhouse climate management under subtropical climate conditions.

The Yangzhou University (YZU, www.yzu.edu.cn) resulted from several merged colleges in 1992. The educational programs include almost all the branches of sciences, with a total of 26,000 undergraduate students. The YZU has a close co-operation with the industry and has established international contacts with other universities, which permits the exchange of researchers and students. The number of foreign students in YZY is increasing. We visited the Vegetable Group, which is conducting research on: breeding of aquatic vegetable crops (e.g. lotus, chestnut and water

bamboo), breeding of fruit vegetable crops and crop physiology and modelling of greenhouse vegetable crops.

The *Jiangsu Academy of Agricultural Sciences* (JAAS, www.jaas.ac.cn) consists of twelve institutes: one English training centre, nine regional agricultural institutes and six municipal vegetable research institutes. Besides that, there are twelve research and development centres and three combined units for research, development and extension. JAAS conducts applied and developmental research and does extension in accordance with provincial and central government politics to develop rural economy, science and technology. JAAS also maintains frequent international exchanges. JAAS ranks as one of the best institutes in China, among the provincial academies of agricultural sciences.

5.4.2 Information sources

The local government has made the effort to combine the resources of research, education and extension for a maximum use of the technical know-how, and to reinforce the link with production and marketing sectors. Currently the agricultural technical service in Jiangsu still consists of 5,419 extension units to support crop production and horticulture among other agricultural areas (Jiangsu Agriculture Government, 2003). In spite of this integration effort and of the huge number of universities, research stations and extension units, it seemed to us that the growers work very much on their own. Co-operation and share of knowledge among different growers is something very rare. Small farmers received good support from research institutes, whereas the big farmers seemed more independent and relaying on the technical advice from their suppliers. For instance, when the big growers were asked about where do they get the knowledge from and how do they solve their problems, the large companies producing anthurium referred that they had technical support from the suppliers in their first years of production, which made them good growers. Also the high-tech vegetable producing companies had advisors coming from The Netherlands (e.g. from Brinkman) during the first years of production. Some other big growers stated that they always solve the problems themselves or that they contact the university professors in case of problems, but this did not seemed to be a very common practice.

According to some university researchers, although the Chinese growers like very much to read 'they only believe in what they see'. Therefore, the best way but to introduce a new product is by showing it (e.g. new cultivar or equipment). This can explain the amount of demonstration centres spread around the province.

5.5 Politics

The Jiangsu province has a clear political strategy to attract foreign investments. Jiangsu was one of the first regions to be open for foreign direct investments in China (Zweig, 2002). In 1995, the Jiangsu Provincial Government has implemented several incentives and established eight 'agricultural export zones', in Changshu, Changzhou, Donghai, Gaochun, Huaiyin, Nantong (in

Rudong County), Sheyang, and Xuzhou (in Fengxian County) to attract investors who could offer advanced agricultural technology, management systems and equipment (Costa, 2003). According to the local agriculture government, Jiangsu will invest in quality, efficiency and export orientation. The agricultural activities will become market-oriented, intensive and modernised. As a result of urbanisation, the better-off farmers will be able to develop metropolitan agriculture. The science and technology will keep improving quality, productivity and efficiency of agriculture (Jiangsu Agriculture Government, 2003).

From our visit, it was very clear that the government has a strong influence on the greenhouse horticultural sector. For example, in some of the modern centres that are governmentally owned but privately run companies, the government decides on the kind of products that should be produced (e.g. vegetables instead of ornamentals) even that according to the manager this is not a profitable choice. In some cases, it seemed to us some modern horticultural companies try to attract more government investment to increase their greenhouse area or to buy sophisticated equipment, even that there was not a real need. For instance, the resources were not always efficiently used since several recently build greenhouses were partly or even totally empty, reflecting a bad management. The strong influence of the government was also felt when some visits to the growers had to be accompanied by a member of the local agriculture government.

5.6 SWOT analysis for the greenhouse horticultural sector in Jiangsu

5.6.1 Strengths

- Highly populated (province with one of the highest population densities and thus big provincial market)
- Location (proximity to large markets: both provincial market and Shanghai municipality)
- Good transport infrastructures (good network of highways and railways; Yangtze River)
- Proximity to the agrochemical industry
- Long tradition in vegetable production
- Largest area of ornamental production
- High quality production of bonsai and anthurium

5.6.2 Weaknesses

- Language: very limited number of managers that speak English (many visit cards and brochures were only available in Chinese)
- Low productivity for vegetables (even in the high-tech greenhouses)
- Lack of specialisation (growers produce a large range of products, especially in pot plant sector)
- Lack of know-how on crop management and pest and disease control
- Poor post-harvest handling of vegetables (no packaging; no refrigerated chain)

- Low water use efficiency (furrow irrigation, open water transport channels, uncovered water reservoirs)
- Lack of co-operation among growers (mainly a trust problem but also due to huge distance between growers)

5.6.3 Opportunities

- Province with relatively high average income (opportunity for high quality products)
- Increase in the volume of supermarkets' sales (where high quality vegetables are better paid)

5.6.4 Threats

- Highly populated (pressure on the land for construction and industry)
- Competition with other provinces (Shandong for vegetables and Yunnan for cut flowers)
- Strong governmental interference in company and production planning
- Water quantity and quality (EC level of the water might increase due to high fertilisation levels and absence of closed fertigation systems)

6.

Shandong province

By J. Miguel Costa and Oliver Körner

Abstract

Shandong is one of the richest provinces of China and one of the most successful regarding greenhouse cultivation of vegetables and fruits. The province has the largest producing area of vegetables in China (1.8 million ha in 2001) and also the largest area of protected cultivation. There are about 200,000 ha of tunnels and 200,000 ha of solar greenhouses. Most of the protected area is used to grow vegetables although the province has also 7,600 ha of fruits growing under shelters. In 2000, pot plants, bonsai, garden shrubs and trees occupied a total area of 14,400 ha.

The diversity of vegetables, fruit and ornamental crops is large. Cucumber and tomato are the most important vegetable crops grown in greenhouses (50-60% of the total area) whereas strawberry, peach and nectarines are the most important fruits species. The diversity of flowering pot plants and bonsai is large but there is a limited number of garden plant species. The quality of bonsai and pot plants is good. Cultivation is mostly in soil and irrigation is mainly by hand or by furrow irrigation. Weifang and Shouguang (Northeast of Shandong) are two important production areas of greenhouse vegetables. Shouguang has 40-50,000 ha of protected area and has one of the 10 largest wholesale vegetable markets of China selling to different parts of the country. Processed vegetables (e.g. asparagus) are also exported abroad. The province attracted foreign investors for different sectors (breeding and seed production, agrochemical industry, vegetable processing). Shandong is expected to remain competitive in vegetable and fruit production relatively to other provinces due to lower labour costs and available know-how. However, water scarcity and the excessive involvement of the government in management may limit growth of the greenhouse industry.

6.1 Introduction

6.1.1 Characterisation of the municipality

Shandong is situated in the east coastal area of China (between 34° N - 38° N and 114 ° E - 122° E (Fig. 6.1A). It has borders with Hebei in the north-west, with Henan in the south-west and Jiangsu in the south-east. It faces the Bohai Sea and the Yellow Sea on the east. The province is mainly plain and covers a total area of 156,700 km^2 with a total population of about 91 million people (ca. 580 inhabitants per km^2). Seventy per cent of the population lives in rural areas (Wang et al., 2003). The capital of the province is Jinan (5.3 million inhabitants), located on the southern bank of the Yellow River and north to the holy mountain *Tai*. The province is located in the warm temperate agricultural climate zone (Chapter 2), and has a semi-humid monsoon climate. Weather conditions vary strongly from the coast to the inland. The mean annual temperature increases from the Northeast to the west and the south. The lowest average temperature is -5 to -1°C in January, and the highest average temperature is 24-28°C in July. The frost-free period near the coast is more than 180 days, but in the inland it is larger than 220 days. The number of annual sun hours varies between 2,400 and 2,600. The average annual precipitation ranges from 560mm to 1170mm increasing from Northwest to Southeast. About 60 to 70% of the annual precipitation is in summer and often in the form of torrential rain. Shandong belongs to the group of seven coastal provinces with an average income per capita above China's average. In 2001, its GDP was €93.0 billion, which was among the top five of China. Shandong also benefits from its richness in natural resources, namely natural sea harbours, gold mining, large deposits of gas, petroleum, coal and iron. Its fast economical development is based on the policy-reform and its political open system, which is in effect since 1978 (OECD, 2001).

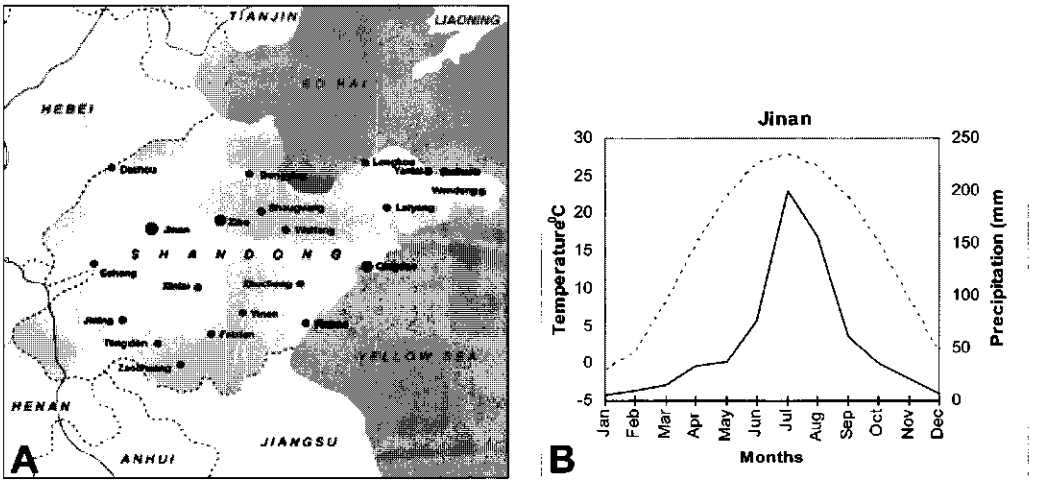

Fig. 6.1: (A) Map of the Shandong province (http://www.maps-of-china.com) and **(B)** average temperature (--------) and precipitation (——) for Jinan city (http://www.fwcc.org/ climate.htm).

6.1.2 Horticultural sector profile

The agricultural area of Shandong covers about 7.7 million ha, about twice the total area of The Netherlands (Post and Zhang, 2003). Shandong is the most important province of China regarding vegetable production (1.85 million ha in 2001; Mello, 2003) and one of the most important provinces regarding protected cultivation (400,000 ha). About 70% of Shandong's vegetable production is sold throughout China. In the Northeast part of Shandong, the city of Weifang, for example, is one of the most important production areas of melons and vegetables in China. Shouguang City in turn, has been awarded with the title of the "*Hometown of Vegetables in China*" due to its tradition in vegetable cultivation (about 40-50,000 ha of greenhouses) and commerce (Guisheng et al., 2003). In 2000, the area of ornamental production in the province was 8,800 ha (mainly pot-plants such as herbal flowers, foliage pot plants and bonsai) and 5,600 ha of ornamental garden shrubs and trees (Dutch Horticultural Board - LNV, 2002). In 2000, the production area of evergreen trees and fruit trees was estimated at 150,000 ha (Post and Zhang, 2003). The area under protected cultivation with fruits was about 7,600 ha (Wang and Anning 2002) although the overall area occupied by fruit trees is 775,000 ha (Post and Zhang, 2003).

6.2 Production Systems

6.2.1 Product diversity and quality

In Shandong province a large variety of vegetables and fruits is produced either in open field or in the greenhouse. The five most important greenhouse vegetables are cucumber, tomato (cherry, beef and round), sweet pepper, hot pepper and egg-plant (Table 6.1). About 50-60% of the total greenhouse vegetable production area is tomato and cucumber. However, also melons and water melons are common in the province and leafy vegetables such as lettuce, celery, garlic, Chinese chive, etc. are cultivated, too. The quality of fresh vegetables is reasonably good and these vegetables are to a large extent (70%) exported to other provinces (Bean and Branson, 2003), in particular to more demanding markets like Beijing. However, there are still limitations regarding exports to foreign markets which are related to deficiencies in the control of the external and internal quality (packaging and grading or residues content, respectively).

The diversity of ornamentals for gardens is rather limited which is typical for provinces above the Yangze river (Post and Zhang, 2003). However, the variety of bonsai ("potted landscape") is rather high (Fig. 6.2). There is also a considerable number of fruit species well adapted to be grown in greenhouses. Strawberries, fruit tree species like nectarines, apricot or cherry growing in small sizes, and grapes are the most important (Wang and Anning, 2002).

There is a large variety of ornamentals grown in Shandong e.g. different varieties of pot chrysanthemum, clivia, azalea, peonia, citrus and anthurium. Due to a strong ongoing construction process of new city gardens and gardening areas along the roads, the nursery sector (garden plants and ornamental trees) progresses and expands fast.

The quality of the ornamental products (pot plants, garden plants) seemed good. The bonsai, in particular, were available in large amount and with good quality (Fig. 6.2).

Table 6.1: Estimated area and average yields for 3 major greenhouse crops grown in the Shandong province.

Crop	Area (ha)	Production [a] (kg/m^2)
Cucumber	53,000	-
Tomato	40,000	25
Eggplant	7,000	10

[a] One season (8 months: September-June as during July-August it is too hot and the greenhouse is empty.

Fig. 6.2: (A) Bonsais and pot plants in an indoor market in Taian and **(B)** fruit trees growing in a solar greenhouse.

6.2.2 Production methods: Substrates, plant nutrition and pesticides

Cultivation of vegetables, ornamentals and fruit trees is basically done in soil. High value substrate as peat is only used for crops like bromelia and poinsettia. Peat comes from other provinces or is imported (e.g. *Pindstrup* from Denmark). The imported peat was mentioned to have a higher quality than Chinese peat, but its price can be also twice as high. Therefore, the imported Danish and the local peat are mixed. In many (solar) greenhouses (e.g. in the Shouguang area), the upper soil layer (up to 30 cm) is a mix of different organic compounds with mainly chicken manure. However, other substrates (e.g. stone-wool and perlite) are being tested in greenhouse cultivation. Also home-made substrates (e.g. pine-cork mixes for azaleas in pot) are used. For azalea propagation (by cuttings) a mix of sand and vermiculite is used. Pot plants like chrysanthemum or other ornamentals were simply potted in normal soil.

There are Chinese and imported chemical fertilisers available. Chinese fertilisers are cheaper (about 30%), but in some cases of lower quality. Therefore, chemical fertilisers are also imported from India, Russia and Germany. Chinese pesticides that are available are considered good by the farmers. The use of pesticides is little controlled (at least for the ornamentals), even after the

government has implemented laws regarding this matter mostly concerning vegetable production (Bean and Branson, 2003).

There are companies using fertigation systems (mostly imported from Israel), although still in a small number. This is because the price of those systems (about € 100 for an average solar greenhouse) is considered to be too high. Although farmer's income per year from a solar greenhouse can reach € 3000 per mu (666 m^2) (e.g. in the Sanguanzhu village) the income in general will be much lower.

6.2.3 Starting material and propagation

Shandong is considered the vegetable production centre of China and also one of the best place for seed production (e.g. vegetables and fruits). It also represents the best market for foreign seeds. Therefore, many seed companies are present in the region.

The Dutch seed company Rijk Zwaan has its main location in the harbour city Qingdao (for seed-import) and it has a demonstration centre in Shouguang (Fig. 6.3). Also companies that are related with governmental research institutes (e.g. the Vegetables Institute of the Shandong Academy of Agricultural Sciences, SAAS) are active in seed trading.

When the seed material from governmental institutes is ready for trading, the extension service delivers new seeds to the farmers via the village representatives. The seed distribution by Rijk Zwaan is based on shops in the different provinces. The price difference between imported and Chinese seed is enormous as imported seed can be as much as 35 times higher in price (e.g. for tomato).

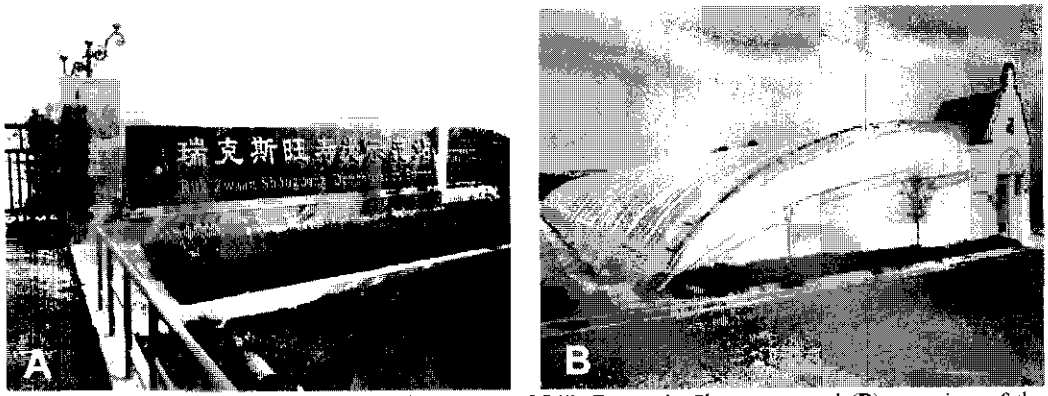

Fig. 6.3: (A) Entrance of the demonstration centre of Rijk Zwaan in Shouguang and **(B)** overview of the solar greenhouse facilities.

6.2.4 Greenhouse structures and equipment

Shandong is the province with the largest area of solar greenhouses (lean-to type) in China. Recent estimations point to 200,000 ha. The same area is estimated for large plastic tunnels. However, it is also possible to find modern structures (multi-span or Venlo-type) used for pot plant production and demonstration purposes or belonging to seed companies. The solar greenhouse was introduced in Shandong in mid 80's and caused a revolution in the protected cultivation as it permitted to cultivate plants in winter without heating. In fact, energy saving in northern China is very important due to costs and limited resources (Wang, personal communication). These greenhouses are managed in a very simple way (empirically according to the experience of the farmers). Little technique is present in the solar greenhouse type and the single-span plastic houses. The construction costs of the solar greenhouse can vary between €690 (for a bamboo structure) and €1970 per mu (€ 1- 3 per m2) depending on the type of the construction materials used. The simplest structure has side walls from clay soil and bamboo as supporting construction (Fig. 6.4A), whereas more expensive structures have brick-walls and metal construction (Figs. 6.4 B). A high percentage of plastic tunnels are large (3.2 m x 8 m x 30 m), but there are also lower and simpler structures (2-2.5m high) built from bamboo and other wood (Fig. 6.4C).

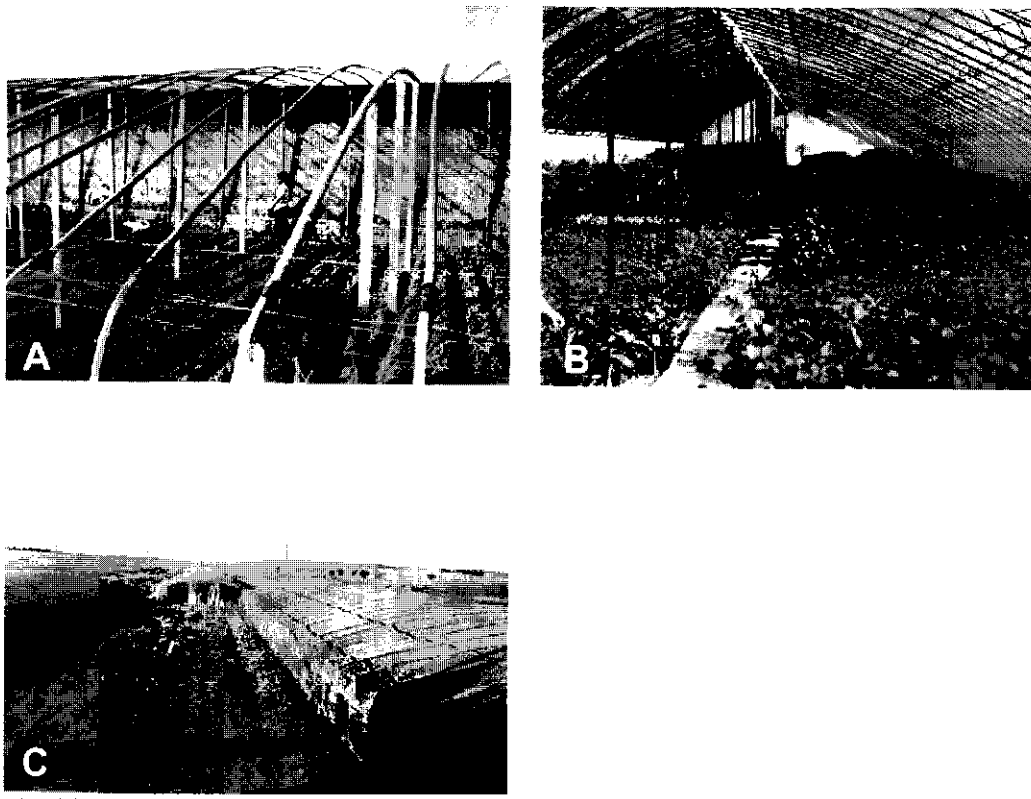

Fig. 6.4: Different types of solar greenhouse structures: **(A)** low cost structure with clay soil side walls and bamboo roof structure and **(B)** a more expensive solar greenhouse with brick walls, metallic roof structure and **(C)** plastic tunnels to grow vegetables near Weifang.

Heating is expensive and therefore very uncommon. Only a minor percentage of the solar greenhouses are heated (Chapter 2). Sometimes mobile coal heating systems are used during the coldest days. The capacity of the solar greenhouse to maintain the heat is very good. During winter-days, the temperature inside of the solar greenhouse during day time can be about 25°C and it drops no lower than 7°C during the coldest winter nights. The temperature can go lower in case there are several days without sun but in general the heat capacity of the north-wall together with the roof isolation provided by the unfolded straw mats is enough to keep the night temperatures in the greenhouses above 7°C during winter. The straw mats are normally unfolded by hand although this task can be automised in more modern solar greenhouses. Straw mats are produced by the companies themselves with small mobile machines or bought from producers (€ 3 per piece). PVC and PE are the most used plastic cover materials and they are produced in China (Fig 4 C).

The modern greenhouse visited near Jinan was equipped with a computerised fertigation system, assimilation lamps, a pad and fan cooling system, insect nets and automised climate control systems (from Israel) (Fig. 6.5). The cost of such a structure (polycarbonate multitunnel) was € 69 per m^2 and it was built by a Chinese company from Hubei.

Fig. 6.5: (A) Outside and **(B)** inside view of a modern Chinese-made polycarbonate greenhouse near Jinan equipped with a pad-and-fan cooling system and an external screen.

6.2.5 Water and environment

According to the locals (officials and farmers), water availability and quality is not a problem in Shandong. Growers could get water from the rivers or from wells. Also Sonneveld (2002) reported that water was not scarce in the south part of the province. This is a little surprising as it contradicts some of the most recent literature stating that Shandong faces a dramatic lack of water (Lohmar et al., 2003; Wang et al., 2003). Wang et al. (2003) for example states that Shandong has only 1/6 of the country's average of water available per capita and because of that it is actively searching for solutions such as sea water desalinisation.

Furrow irrigation is widely used in open field as well as in greenhouse cultivation whereas drip irrigation and fertigation are common in more modern greenhouse structures including the more modern solar greenhouses.

Soil desinfection is by chemicals such as methyl bromide. Another strategy followed consists in a type of solarisation, in which the solar greenhouse is totally closed during summer (i.e. July-August) and inside air temperature can rise up to 80°C. However soil temperature is lower (about 60 °C in the top soil layer) which decreases the efficiency of the method. Next to diseases, salinisation is a problem affecting greenhouse soils. This is promoted by the intensive use of the soils for producing always the same crop (Van der Lee, 2003).

Chemical crop protection is common. However, integrated crop demonstration centres have been founded in Shandong (Yong-Gong and Guo-Jun, 2002). It is possible that a lack of know-how regarding greenhouse climate control results in a combination of high relative humidity and high temperatures which increase the incidence of diseases and consequently the use of pesticides. Like in other provinces, old and used greenhouse plastics are bought and collected from farms by plastic recycling companies, several of them located in the province.

6.3 Marketing, commerce and logistics

6.3.1 Marketing and commerce

Shandong has different types of markets for vegetables and ornamentals, mostly located in the big cities. There are several hundreds of wholesale markets in the province. The most important vegetable trading place is in Shouguang, near Weifang (*The Shouguang Vegetable Wholesale Market).* This market is one of the 10 largest wholesale markets of agricultural and sideline products in China.

The annual trade volume is € 273 million. Its distribution market area covers almost the whole of China. Shandong is also exporting to abroad, mostly processed vegetables (canned asparagus and mushrooms for example) to USA, Japan, EU (Bean and Branson, 2003). There are foreign-owned companies working and supplying Singapore or Japan markets. Organic produce is also exported to USA, Canada and the EU. This is based on contracts. In the wholesale market, product handling and packaging is often rough and products get visibly damaged. The only visible improvement that products received was the removal of damaged and older leaves (e.g. cabbages) and the packaging of different products in plastic net bags (Fig. 6.6).

Fig. 6.6: Overview of the Shouguang Vegetable Wholesale Market.

The (indoor) markets for pot plants and flowers (e.g. *Xiaojing Flower Market* or *South ShangGao* near Taian) are typical commerce structures. Like the wholesale market, the building is governmental property (Fig. 6.7A). The market-stand owners have to pay a rent of € 0.3-0.6 per m^2 each month (depending on location in the building). There is a large variety of ornamentals (e.g. *Cycas revoluta, Araucaria excelsa, Ficus elastica),* azalea and potplants like kalanchoe, poinsettia, bromelia, and bougainvillea were imported from other provinces (e.g. Guangzhou, Beijing) or even from abroad (The Netherlands) like bromelia and calathea. These plants were first imported via Shanghai and then distributed to different parts of China (Fig. 6.7B).

In some cases several growers were organised in a co-operative and these growers sell their products under one label (e.g. *Wanhong Flower Company of Shandong)* in the Jinan area. This grower's co-operative rents a large area of the market for a long period (30 years). The main customers for the ornamentals are governmental officials, larger companies and hotels. The tendency is still towards an increase in demand.

Street markets are also good places to commercialise ornamentals, vegetables, fruits and pottery (Fig. 6.7C). The direct marketing from the grower to the customer in the small outdoor markets avoids the middle-men and farmers can receive higher prices. A list of prices of vegetables and cut flowers is provided in Tables 6.3 and 6.4. The supermarkets offer vegetables and fruits, better packaged and apparently more information can be provided about how vegetables were grown in order to demonstrate the safety and quality of the product.

Fig. 6.7: **(A)** Indoor pot plant market in Taian and **(B)** paper box with imported calatheas from the Netherlands; **(C)** Street market in Taian.

Table 6.2: Indicative prices of vegetables in a street market in Taian (end October).

Species	Price €/kg
Aubergine	0.30
Broad beans	0.32
Brocolli	0.32
Carrots	0.12
Cauliflower	0.30
Chinese cabbage	0.12
Cucumber	0.29
Hot pepper	0.26
Pepper	0.30
Radish	0.16
Tomato	0.30
Tomato (small)	0.60

Table 6.3: Prices of cut flowers at the flower market in Jinan (end October).

Species	Price (€)
Carnation (bunch 20; short stem)	0.49
Chrysanthemum (bunch of 20)	0.98
Gerbera (bunch of 20)	0.69
Gladiolus (1 stem)	0.10
Rose (bunch of 12)	1.18

6.3.2 Logistics

The transport of vegetables is mostly done by road in overloaded trucks. The trucks used for transport are non-refrigerated and often open on the top. The products (e.g. Chinese cabbage) are adjusted with ropes and in general no protection is used (Fig. 6.8A). In winter truck loads can be isolated with straw mats. Cauliflower, with a high respiration rate, will easily start heating up too much when packed on a overloaded truck. Also for pot plant and flower transport, trucks are not refrigerated (Fig. 6.8B). For the transport of vegetables there is a particular regime for transportation of vegetables from Shouguang to Beijing as the "*Green Channel*" has been established since 1995.

The development of the road infrastructure is remarkable as almost all major cities of the province are connected with new high quality high-ways. Construction of new rail connections is also going on. At present the province has several important railways. The Beijing-Shanghai and the newly built Beijing-Kowloon railways run north-south across the province and the Qingdao-Jinan and Rizhao-Shiyan railways traverse it from east to west (http://www.china.org.cn/english/features/51617.htm) which enables the transport of goods to the big metropolis or the harbours or vice-versa. Shandong has a long coast and several international harbours ports. One of the most important is Qingdao from which many vegetables are exported to Japan. Due to the 9 civil airports, an easy connection to South Korea and Hong Kong is permitted and Shandong's exporting activity is facilitated although this is a too expensive way of transport for the horticultural produce.

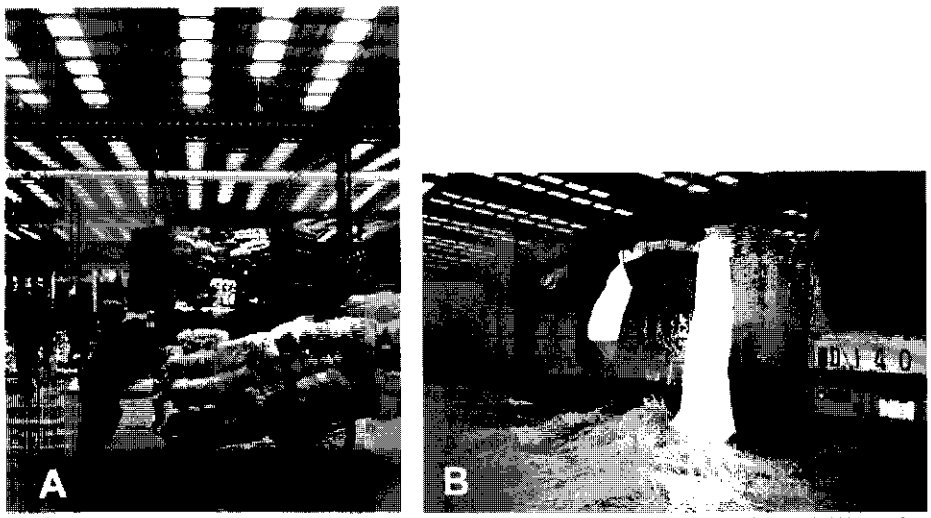

Fig. 6.8: (A) Truck with Chinese cabbage at the *Shouguang Whole Sale Market* and **(B)** truck covered with plastic and straw for transport of cauliflower during the cold period.

6.4 Research, Education and Information Sources

There are several important research institutions in this province, for example the *Shandong Institute of Pomology* of the *Shandong Academy of Agricultural Sciences* (SAAS[2]) in Taian (http://www.sdip.ac.cn/eindex.htm), the *Shandong Vegetable Institute* of SAAS in Jinan (http://www.saas.ac.cn/english/default.htm) and *Shandong Agricultural University* in Taian (SAU; http://www.sdau.edu.cn/esdau/new/). SAAS and SAU are 100% governmentally financed and their projects on horticulture include greenhouse engineering and greenhouse climate control, post harvest quality and breeding. SAU has a total of 15,000 students and developed into a multi-disciplined agricultural university with agriculture, forestry and hydraulics as their primary focuses. Foreign universities have a high reputation in Shandong, especially Wageningen University and co-operation is strongly desired.

SAAS has several agencies for technical services as the *Food Quality Monitoring Centre,* the *Crop Seed Testing Center*, an appointed laboratory for *China Green Food Monitoring* and other important province laboratories. The main function of SAAS is to: 1) enhance applications and develop research programmes based on the agriculture problems of the province; 2) develop and extend the achievements in agriculture research and practical techniques; 3) compile magazines in agricultural science and 4) develop co-operation and exchange programs in agricultural science and technology within and outside the province. The *Shandong Vegetable Institute* from SAAS is also working on a new concept of a solar greenhouse with dehumidification systems and under ground heat storage systems. One of their main focus is breeding tomato varieties that are adapted to low light and low temperature and that are resistant to early and late blight. SAAS had already co-operated with some foreign private seed companies in the pass.

The *Shandong Institute of Pomology* is one of the most relevant institutions in Shandong because of the importance of the fruticulture in the province. The institute was founded in 1956 and aims at conducting research in different aspects of deciduous fruits (e.g. germplasm resources, cultivation practices, breeding, storage and processing, prevention of diseases and pests). The staff is 240 people of which about 100 are specialised scientists. The institute co-operates with the Shandong Agriculture University from which has resulted the quarterly journal "Deciduous Fruits".

The Dutch established a new training center in Shandong resulting from an agreement between the *Province Noord Holland* and the Shandong province (Van der Lee, 2003). The training center is in the hands of the *Weifang Science and Technology Vocational College* and has several greenhouses for demonstration of flowers and vegetable cultivation. Some Dutch companies from the floriculture and seed sectors are involved in the project. Besides the Dutch, also Israeli companies are active in Shandong. A big demonstration farm is e.g. located in the city of Weifang.

The most important sources of information for farmers regarding crop protection are the extension services or local pesticides providers, horticultural magazines and the TV. Farmers are also informed via demonstration farms either governmental (e.g. the *EASV- Shouguang Demonstration Area of Vegetables High Science and Technology)* or private (e.g. *Rijk Zwaan*)

about the new vegetable varieties. Demonstration centres are the best way to introduce farmers to the new cultivars ("seeing is believing") The *High Science and Technology Agriculture Demonstration Centre* has 500 solar greenhouses and 100 employees (Fig. 6.3B).

6.5 Politics

Large production companies and research centres are directly or indirectly influenced by the provincial government as the management is performed by governmental officials. The agricultural sector is one of the most important for foreign investors. Shandong is good in attracting foreign investment (like Jiangsu and Shanghai) due to the tax politics of the government. The government grants 2 years tax-free operations for new companies (Shields and Tuan, 2001). This reflects positively on the agricultural/horticultural sector and in particular in the processing and marketing of vegetables and fruits. Singapore and Japan are two of the major investors in the province. A company from Singapore invested in a large greenhouse/packing facility north of Qingdao to export to Japan and Singapore (Shields and Tuan, 2001). The government also intends to increase the gardened area of the province (e.g. in Qingdao due to the Olympic Water Games in 2008).

6.6 SWOT analysis for the greenhouse horticultural sector in Shandong

6.6.1 Strengths

- Concentrates large area of greenhouses and horticultural suppliers (fertilisers, seeds, plastics) (cluster)
- Large wholesale market for vegetables
- More open to purchase of foreign seeds compared to other provinces
- Labour costs lower than other provinces or municipalities (e.g. Beijing, Shanghai)
- Tradition in production and commerce on vegetables
- Transport infrastructures (improved road network, sea harbours e.g. Qingdao)
- Relatively close to major consumer centers (e.g. Beijing)

6.6.2 Weaknesses

- Limited investment possibilities / Many small companies
- Quality of the product (packing, grading, quality control)
- None or limited cool chain (e.g. no refrigerated transport)
- Few people sppeaking English

6.6.3 Opportunities

- Low wages
- Preferential relation with Beijing ("Green Channel" for vegetables)

- Increased demand for vegetables in other provinces

6.6.4 Threats

- Increased competition from other typical vegetable producing provinces (e.g. Jiangsu)
- Market has low prices (over supply and saturation)
- Lack of market information (low profit for growers)

7.

Yunnan province

By Anke Van der Ploeg and Niek Botden

Abstract

Yunnan is located in the southwestern part of China and benefits from favorable climate conditions (mild climate all year round) for ornamental production. For this reason, Yunnan has become the most important cut flower production area in China, accounting for 50% of China's total cut flower production. In 2002, the total area for ornamental production was estimated to be 6,250 ha, 60% of which is used for cut flower/foliage production. Ninety percent of the total ornamental production is produced under some kind of shelter, mainly plastic tunnels. Vegetables and fruits are grown on a much larger area (400,000 ha) and are mostly grown in the open field. The diversity of ornamental and vegetable crops is large. The main cut flowers are carnation, rose, lily and gypsophyla. Carnation and rose represent about 70% of the total cut flower production area but many other species are produced on a smaller scale like gerbera, gladiolus, limonium, chrysanthemum or statice. Cut foliage species like phylodendron, palm leaves and lycopodium are also produced in Yunnan. Small scale family-based production occupies the largest area but large scale production by both governmental and private companies is on the rise. Commercialisation of ornamentals is done via wholesale markets, street markets and via the recently founded auction (KIFA) which is based on the Dutch auction model. A major weakness of the greenhouse horticultural sector in Yunnan is the long distance to the main Chinese and foreign markets. Moreover, logistics are far from optimised, refrigerated transport is often not available and air flights to the main export markets are absent. Even so, the aim of the province is to become the export leader for cut flowers in China and South-East Asia. A new high way to Bangkok is built and an auction was recently opened.

7.1 Introduction

7.1.1 Characterisation of the municipality

Yunnan is situated in the southwest of China (97° - 106° E and 21° - 29° N) and has a total area of 394,000 km^2. It is surrounded by Tibet and Sichuan in the North and Guizhou and Guangxi in the East. In the south and the west it borders to Vietnam, Laos and Myanmar (Fig. 7.1A). The province has a population of 42.9 million of whom 4.9 million live in the capital Kunming (NBSO, 2003). The northwestern part of the province has mountains which can rise over 5,000 m above sea-level whereas the southern part has tropical river valleys which lie only 80 m above sea-level. The province is part of the Middle and South Tropical agricultural climate zones (Chapter 2). From north to south Yunnan spans three types of climate: temperate, subtropical and tropical. Due to the Pacific and Indian Ocean currents, the dry and wet seasons are evident, with the rainy season from May till October. The annual precipitation varies between 600 mm in the northwest and 2,300 mm in the southeast (FAS-USDA, 2003). Kunming has an average of 2,400 sun hours per year and the average relative humidity is 74%. The average temperature is between 8 and 17°C in January and between 11 and 29°C in July. Because of the mild climate all year round (Fig. 7.1B) the capital Kunming is nicknamed "city of eternal spring"

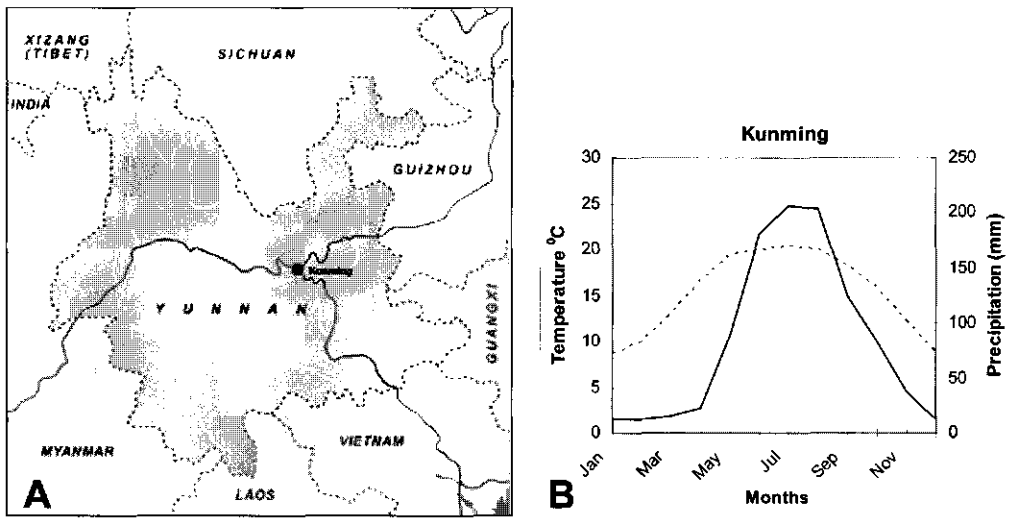

Fig. 7.1: (A) Map of Yunnan province (http://www.maps-of-china.com) and **(B)** average temperature (------) and precipitation (——) in Kunming (http://www.fwcc.org/climate.htm).

Since opening-up and reform policies started more than 20 years ago, Yunnan has undergone rapid economic and social development. With an economic growth rate of about 10% for more than 10 consecutive years, Yunnan's GDP reached € 207.5 billion in 2001 (NBSO, 2003). Even so, Yunnan still belongs to the group of poor provinces of China only ranking on the 17th place in China. Yunnan is opening to the world, guided by the opening-up policy of the central government and can be considered a gateway of southwest China to Southeast Asia and the world (Yunnan Flower Association, 2003). Yunnan's economy runs on tobacco production, the tourist industry and the floricultural industry. Contrary to the tobacco industry, which is declining, the floricultural industry is expanding with the support of the local government who believes that strengthening the floricultural industry will also attract even more tourists. Due to its broad range of altitudes and diverse climate, a wide range of plant species is native in Yunnan. From the highlands in the north to the low areas in the south, there are temperate alpine, sub-tropical and tropical plant species. Yunnan has 18,000 higher plant species which represent more than 50% of the total number of higher plant species existing in China. There are also numerous species of cash-generating trees. Among Yunnan's plant resources, there are over 10,000 species of tropical and sub-tropical plants, 2,000 kinds of herbal plants, 400 kinds of spices, 2,100 species of ornamental plants and 1,500 species of flowering plants. Therefore, Yunnan deserves its fame as the "Kingdom of Plants" (Yunnan Flower Association, 2003).

7.1.2 Horticultural sector profile

The flower industry in Yunnan started at the end of the 80's. Yunnan has become the leading province of cut flower production in China, with an output of 1.3 billion stems in 2001, accounting for about 50% of the total production in China (NBSO, 2003). The planting area for cut flowers increased from around 600 ha in 1995 to over 3,750 ha in 2002 (Fig. 7.2). In 2002, the cultivation area of cut flowers, ornamental and foliage plants in Yunnan was about 6,250 ha with a total turnover of €3.4 billion (NBSO, 2003).

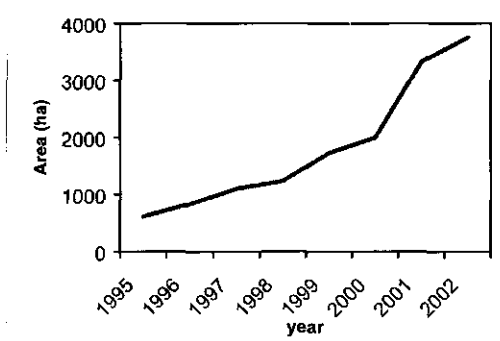

Fig. 7.2: Area of cut flower production in Yunnan between 1995 and 2002 (Yunnan Flower Association, 2003; NBSO, 2003).

In 2002, there were 365 flower enterprises in Yunnan, including state-owned enterprises, stock enterprises, private enterprises, foreign companies, joint ventures and cooperative companies. Until 1999, altogether 21 enterprises belong to foreigner investors (Yunnan Flower Association, 2003). However, it is difficult to determine whether the investments from Hong Kong and Taiwan are considered foreign.

Yunnan has three main flower production zones: 1) the districts of Lijiang and Zhongdian in the northwest (flower bulbs and cut flowers), 2) the districts of Jinhong, Yuanjiang and Hekou in the south (tropical orchids, cut flowers and indoor foliage plants) and 3) the districts of Kunming and Yuxi in the central part of the province (sub-tropical cut flowers and tropical orchids). According to the NBSO (2002) there is around 46,000 ha of flatland and valley suited for flower growing in Kunming and Yuxi.

Yunnan is focussed on developing cut flower production in greenhouse, but the cultivation area of fruits and vegetables is much larger and has increased considerably in the last 12 years. In 2002, there were about 400,000 ha planted with vegetables, almost 4 times the area in 1990 (Potash and Phosphate Institute, 2003). Most of the vegetables are grown in the open field.

Labour is abundantly available in the province but some employees who carry out low skilled work come from neighbouring provinces due to lower labour prices. Labour conditions vary between companies. In one company people had to work 7 days per week, at least 10 hours per day with only 3 days off per month, while in another company carnations were grown on elevated benches to improve labour circumstances for the employees.

In general, Yunnan horticultural companies can be divided in three groups. The first, and by far the biggest, includes local small scale farmers, who own a small piece of land given by the government (about 0.2 ha per family). The size is based on family size. Small farmers mainly grow vegetables for their own consumption and to sell to local markets. But they also grow a wide range of cut flowers (e.g. gypsophyla, carnation, rose and lilies), which are sold to local wholesale markets.

There is little co-operation among farmers, although they understand that one village is good in producing one crop and another village is good in producing another crop. This generates three major problems: low and varying product quality, over-supply and a lack of marketing power. The government is therefore trying to organise small local farmers in co-operatives. These co-operatives are then able to buy seeds, fertilizer and chemicals in larger amounts with better deals. The co-operatives should also make it possible that farmers get technical support and participate in research (with the support of research institutes and *Yunnan Agricultural University*). However, the number of these co-operatives is still limited.

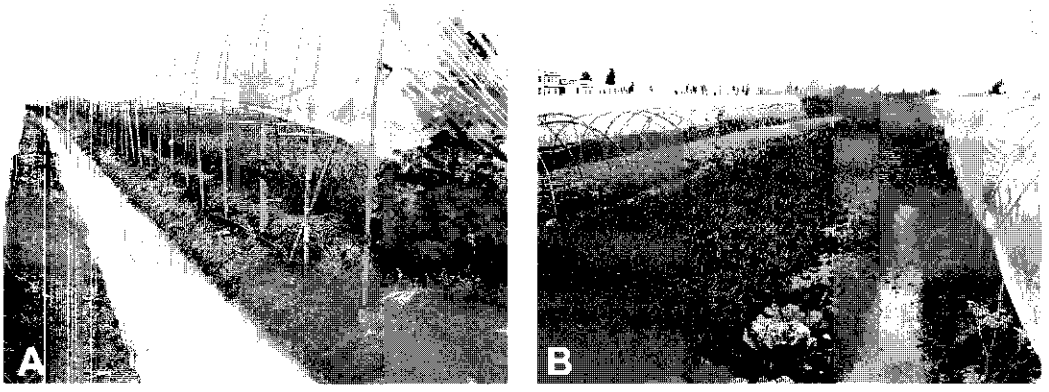

Fig. 7.3: (A) Small scale production of carnation in simple greenhouse structures built with bamboo canes and covered with plastic and **(B)** open field production of vegetables by small farmers.

The second group includes the large governmental and/or semi-governmental companies. In these companies, planning is deficient. First a greenhouse is build and only then one decides what to grow. These companies usually work as governmental demonstration centres and management often lacks experience in horticultural production. Besides, management is sometimes more concerned about other matters than successfully running the company. This may result in much lower production levels (e.g. roses that are pruned too high and not bended properly). The initial investment in greenhouse structures is usually not considered and only variable costs are accounted. Therefore, most companies are assumed to be "profitable". This leads also to artificially low cost products, which represents unfair competition for the privately owned companies. However, the government itself starts to realize that these (semi)-owned companies need to work more efficiently and produce higher quality products in order to be competitive. The companies themselves have often a very top-down managed structure. Products are usually traded locally and regionally and only a small part is exported.

The third group of horticultural companies includes the private companies, which have been founded in the last decade with the support of their foreign mother companies mainly from Taiwan, Hong Kong and the USA. Investments via Taiwan and Hong Kong are very attractive, due to special tax politics. The investing companies are not necessarily from the agricultural sector but realize the potential of investing in horticultural production. Most private investors in production and post-harvest logistics in Yunnan are non-horticultural firms. The production area of these companies is often large (10 to 50 hectares). These companies have better know-how on crop management and production techniques. Decisions are carefully taken after trials. These companies often use modern plastic greenhouses and they are not only focussed on producing high quality products but also on the supply chain. They sometimes buy products from small local farmers, which they provide with starting material. Therefore, these farmers act as contract growers. Production is in large extent exported to South-East Asia and Japan. Like the big governmental companies, private companies respect breeders rights. International breeders and/or starting material

suppliers give these companies a "license to produce", a business-to-business agreement since breeders rights in China are neither well developed nor fully enforced. Although private cut flower companies employ local people, these companies work isolated in Yunnan. They get plant material, production materials and tools from abroad, produce in Yunnan and export the production. The private companies are often part of an international network. The main reasons for their presence in Yunnan are the excellent climate and the cheap labour.

7.2 Production systems

7.2.1 Product diversity and quality

The diversity of ornamental and vegetable crops is large. The main cut flowers are carnation, rose, lily and gypsophyla which occupy 35%, 32%, 8% and 6%, respectively, of the total cut flower production area. Many other cut flowers are produced on a smaller scale (e.g. forget-me-not, gerbera, gladiolus, limonium, chrysanthemum, statice etc.; Dutch Horticultural Board - LNV, 2002; NBSO, 2002). Also a number of green cut foliages is produced (e.g. phylodendron, palm leaves, lycopodium).

Due to plant variety protection the small growers are usually not able to obtain the newest varieties. Only the bigger private and governmental companies have business-to-business agreements. Companies that do not have such agreements have limited possibilities for exporting their products to Japan and Europe. Therefore, many big growers understand the importance of paying breeders rights.

Major problems in cut flower production are pests and diseases. Knowledge on pest management and prevention is generally low within the group of local small farmers and within management of governmental farms. Another problem are the post-harvest diseases. The chain is not optimised, mainly due to a lack of knowledge and this limits the prospects of selling to distant markets.

Private companies understand better how to prevent diseases in the supply chain. Packing is better and also a cooled post-harvest chain is available. They often sell their products directly, making it easier to attain an optimised post-harvest supply chain to the final customer. In order to put the ornamental products in good quality to the markets, exporting private companies organise the post-harvest chain and logistics themselves; they keep track of the product and handle it with the necessary care.

Chinese and imported mixtures of flower preservatives are available in the market. . In fact, the Yunnan chemical industry has its own products on the market as the international brands preservatives are considered expensive.

In general it can be stated that the quality of pot plants (e.g. phalaenopsis, pointsettia, cyclamen, begonia, pot chrysanthemum, pot anthurium, petunia, nephrolepsis, geranium etc.) is

good compared to international standards. The quality of produced cut flowers is sufficient to good in private companies, reasonable for (semi) governmental companies and reasonable to low for small farmers.

Also for vegetable export (e.g. different types of cabbages, carrots, sugar beets, broccoli, carrots, radish etc.) it is important to achieve higher quality standards. and reduced pesticide use. Japan for example is asking for low residue or even pesticide-free products. There are governmental organisations to check the amount of chemical residues on the crop and decide whether a crop can be exported or not.

7.2.2 Production methods, substrates and plant nutrition

Small farmers grow their vegetable and flower crops in soil because it is cheap. The visited governmental and private companies also cultivate cut flowers in soil (e.g. roses). The majority of soils are highly acid and not fertile. Past research has shown that Yunnan soils were deficient in phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), boron (B) and molybdenum (Mo) (Potash and Phosphate Institute, 2003). Pot plants are usually grown in a mixture of local soil with local peat or in a mix of local peat with perlite. Imported peat (from South Korea or Germany) is only used for more rare species, because the price of imported peat is considered too high. Many companies use organic fertilisers as main source of plant nutrition. In addition locally produced chemical fertilizers are used when the organic fertiliser is not sufficient. Chemical fertiliser are also imported (e.g. Japan) although these products are in general too expensive.

Potplants were grown on anti-rooting canvas (Fig. 7.4A) whereas vegetable seedlings and carnation and chrysanthemum mother plants were grown on elevated benches (Fig. 7.4B and 7.4D). Carnations and lilies were grown in soil benches (Fig. 7.4C).

7.2.3 Starting material and propagation

Vegetable seeds are mainly supplied by governmental local companies, although some companies import seeds from Israel (sweet pepper), Japan (cucumber) and South Korea (radish). Cuttings for cut flowers are imported from The Netherlands (carnation) and Japan (chrysanthemum). Bulbs are mainly imported from The Netherlands. Some of the private companies had problems with getting good suppliers in the beginning because they felt they were not taken seriously by supplying companies. This was mainly based on a lack of trust by the supplying company, since they did not deliver the newest varieties and crop information. Private or semi-governmental companies that respect breeders rights can establish some business-to-business agreements with the breeding companies and obtain a licence-to-produce. This enables companies to have the right cultivars, achieve higher yields and good quality for export markets. These agreements also guarantee after-sales information by breeders.

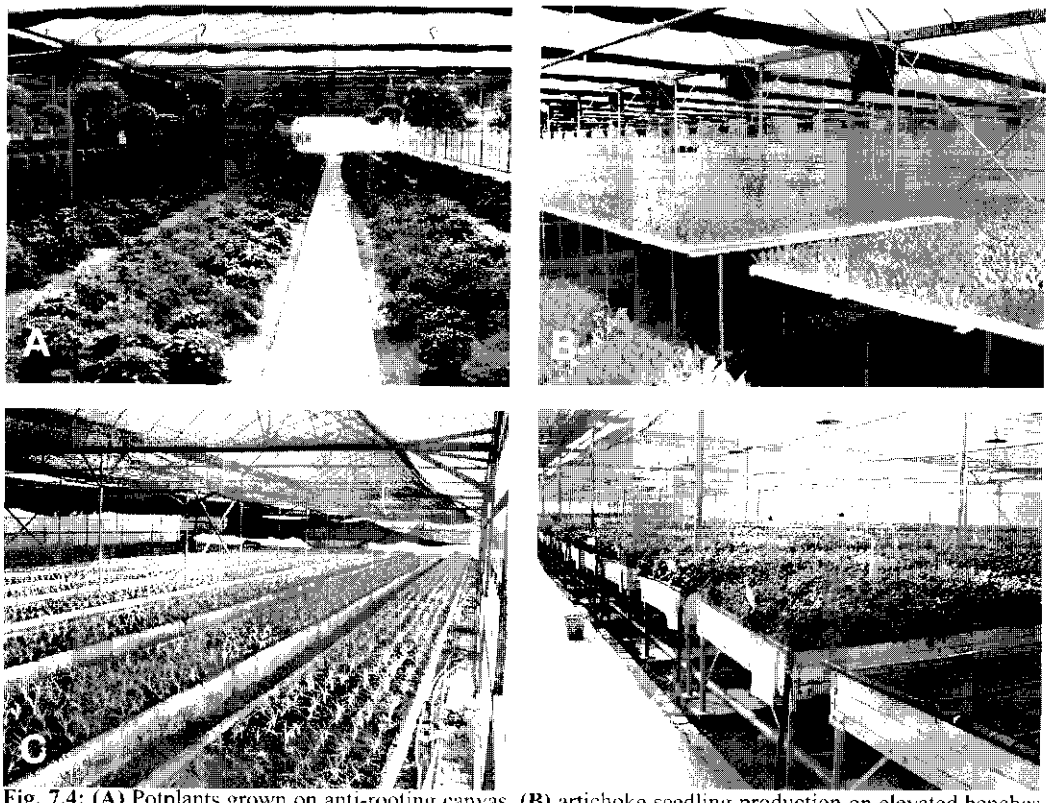

Fig. 7.4: **(A)** Potplants grown on anti-rooting canvas, **(B)** artichoke seedling production on elevated benches and **(C)** recently planted carnation plants grown in soil beds and **(D)** chrysanthemum mother plants grown in elevated benches with fertigation

7.2.4 Greenhouse structures and equipment

About 80% of the flowers in Yunnan are produced under protection (Dutch Horticultural Board - LNV, 2002). About 90% of the ornamental production is done in simple plastic tunnel greenhouses or only protected by 'light screens' (Wang, 2001). Until 1999, Yunnan imported 14 ha of greenhouses from abroad and built 150 ha of steel frame greenhouses made in China (Yunnan Flower Association, 2003). In general, only plastic greenhouses are used. Small farmers commonly have low-cost plastic tunnels, which are constructed by bending bamboo and/or iron and covering this with single layer plastic (Fig. 7.5A). The size of one tunnel is usually 666 m^2. Around the tunnels, there are ditches to drain the often wet clay soil but also to provide water for irrigation (Fig. 7.3). The more advanced plastic multi-tunnel greenhouses used by the governmental and private companies are imported from Israel, Spain or France or manufactured in China (Fig. 7.5B). Chinese companies started to imitate imported greenhouses after the government invested in the so-called demonstration projects (Chapter 2).

There are several small greenhouse manufactures in Yunnan. Each of them designs and builds about 10 ha of greenhouses each year in Yunnan and in other provinces. Some private companies just order the greenhouse material and build the structure themselves. Prices of the greenhouses start at €10 per m^2 for a plastic greenhouse and up to €69 per m^2 for a glasshouse (only used for demonstration or research purposes). Almost all greenhouse components are produced in China, but certain parts (difficult to copy) such as the window opening mechanism and irrigation systems are still imported (mainly from The Netherlands and Israel). Climate control is done manually by opening and closing the side wall and top ventilation. Simple black nets are used as shading screens inside the greenhouse. Greenhouses can be heated by coal burners during winter.

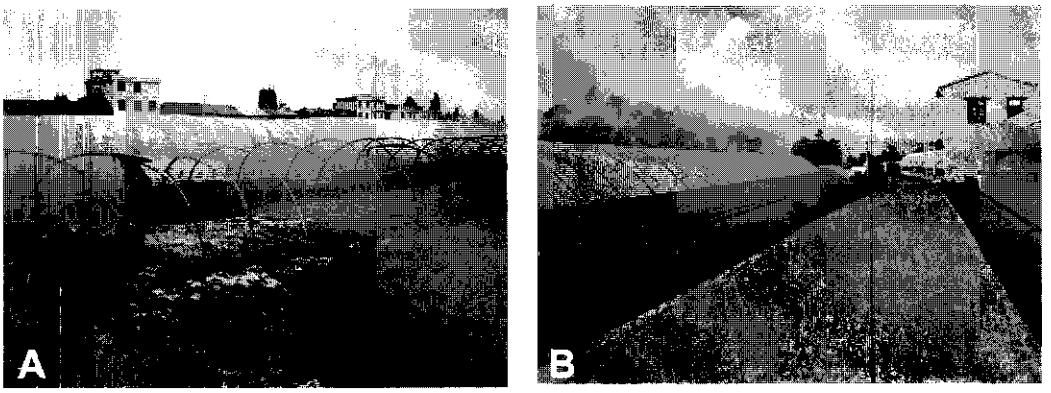

Fig. 7.5: **(A)** Plastic tunnels constructed with bended bamboo covered with plastic and belonging to small farmers **(B)** Chinese manufactured multi-tunnel greenhouse from a large private company

7.2.5 Water and environment

Water availability is not a problem in this region of China. Irrigation water used in governmental and private companies is mainly from the ground or mountain water (EC=0.3). In certain regions the ground water has the problem of a too high pH due to a high calcium content. Small local farmers use surface water. Irrigation for soil growing is mainly by sprinklers or by drip irrigation, using perforated tubes. Drip irrigation is also used when growing in elevated benches (Fig. 7.4D). In potplant production, watering is sometimes done manually, but mainly via drip irrigation by using drifters. Until 1999, Yunnan enterprises introduced and installed 30 ha of automatic control irrigation systems and 200 ha of semi-automatic or simple drip irrigation systems (Yunnan Flower Association, 2003).

Insects are a big problem in production, resulting in a high amount of pesticides used. Thus, pest control counts for a large part of the cost price. Biological control is hardly used, although some private companies do some small-scale tests. Most of the more advanced plastic greenhouses do not have insect screens and it is therefore difficult to keep pests out. Most of the chemicals come from the local market because of their low price but some private companies import part of their

biocides from abroad. Quality and distribution of pesticides are problematic as an estimated 30 to 40% of the pesticides on the market is sold under false brand names and at least half of the pesticide distributors is not legally registered or licensed (PANNA, 2003).

Fungi like powdery mildew, downy mildew and *Botrytis cinerea* are also a big problem. The knowledge how to prevent these diseases with climate control is generally low, especially on governmental and small farms. The used plastic-covers of the greenhouses that are produced locally are recycled after one or two years of use, while imported plastic is used for 4 to 7 years before recycling.

7.3 Marketing, Commerce and Logistics

7.3.1 Marketing and Commerce

Eighty percent of Yunnan's ornamental production is sold to more than 70 big and middle sized cities in China. Ten percent of the production is exported (mainly to Japan, Thailand, Singapore, South Korea, Taiwan, Hong Kong) and the remaining 10% is sold locally. The main target of the Yunnan floricultural industry is to become the largest flower production and trading centre in southeast Asia. Yunnan is focussing in general on domestic markets and neighbouring Asian markets (such as Japan, Hong Kong, Macao and Taiwan).

At present, there are two main marketing channels for the Yunnan ornamental production:

1. Small farmers, (semi)-governmental companies and private enterprises sell to the flower whole sale markets. On these markets, the growers try to sell their products to traders. The traders buy flowers and ornamental plants and deliver this product to their own commission agents, local wholesale market or retailers. The final outlets are then mainly regional or within China. The chain is very much supply driven, transaction volumes are rather small and buyer-seller relations act in a network structure.
2. Larger enterprises sell via direct chains to clients on national or international markets. The transaction volumes are much larger and the supply chains are more professional and organised. The supply chain is partly supply and partly demand-driven and buyer-seller relations are acting more in stable chain structures with increasing amount of information flowing both upstream and downstream of the chain.

Eighty percent of the total production is traded via the *Dounan Wholesale Flower Market,* located in Chenggong county, near Kunming (Yunnan Flower Association, 2003). The market (Fig. 7.6C) covers an area of 1.2 ha and every day about 3 million stems of cut flowers and 12 tons of cut foliage are traded by about 4,000 traders (NBSO, 2002).

The private and (semi) governmental enterprises discovered the need for co-operation to increase marketing power and benefit from economies of scale. The floricultural companies are too small by themselves to be able to produce a diversity of high quality products on schedule at certain

prices based on world market demands. This was the driving force to start the *Yunnan Flower Association* (YFA). Enterprises and growers can join the YFA voluntarily. In this organisation there are 65 companies engaged in flower production, processing, marketing, research, storage & transportation.

To raise the circulation efficiency, the *Kunming International Flora Auction* (KIFA) was founded and is located next to the *Dounan Wholesale Flower Market.* By starting the KIFA, the provincial government aimed at creating a market place, where supply and demand can meet each other. The KIFA auctioning system (Fig. 7.6A and B) is based on the *Aalsmeer Flower Auction* (VBA). KIFA is focussing on the top quality market and distinguish themselves from the *Dounan Wholesale Flower Market* with a large volume, guaranteed high quality and a full pre- and after sales service. With the KIFA auction, Yunnan hopes to attract (international) buyers, who want diversity in products with a guaranteed quality at a given time and all in one location. The auction just opened recently and at the moment the amount of products sold via the auction is small. However, the start is there.

KIFA was established as joint initiative of the Yunnan provincial government, Kunming municipality, Chenggong county and the *Yunda Science and Technology Stock Co., Ltd.* The total investment was €13.2 million and an area of 9 ha is used. Meanwhile, KIFA also conducts other businesses like producing and marketing of flowers, young plants and the relevant horticultural facilities & equipment such as, fertilizer and special pesticides. KIFA aims to promote modernisation and internationalisation of Yunnan floriculture industry through the auction system and become come the largest flower trade centre in China (and Asia).

A major problem with KIFA is its organisational set up and its governmental structure. Therefore KIFA is not totally independent from the government. Besides this, also management problems (e.g. bureaucracy, politics and lack of experienced or educated personal) slow down the development of the auction. At present, the auction is assumed to be a profitable investment by the government or semi-governmental investors. In the future, however, KIFA must become independent and the stocks should be in the hands of users, who need the market place for buying or selling their products. In addition, the whole organisation should be managed objectively with a non-profit-drive.

Besides KIFA, Yunnan government also started a logistical service company that should organise all logistical matters from the production and/or market place towards the final buyers. This company should add service to the whole supply chain. However, the Yunnan government gave trade rights to this company and as a consequence it is competing with (rather then serving) KIFA.

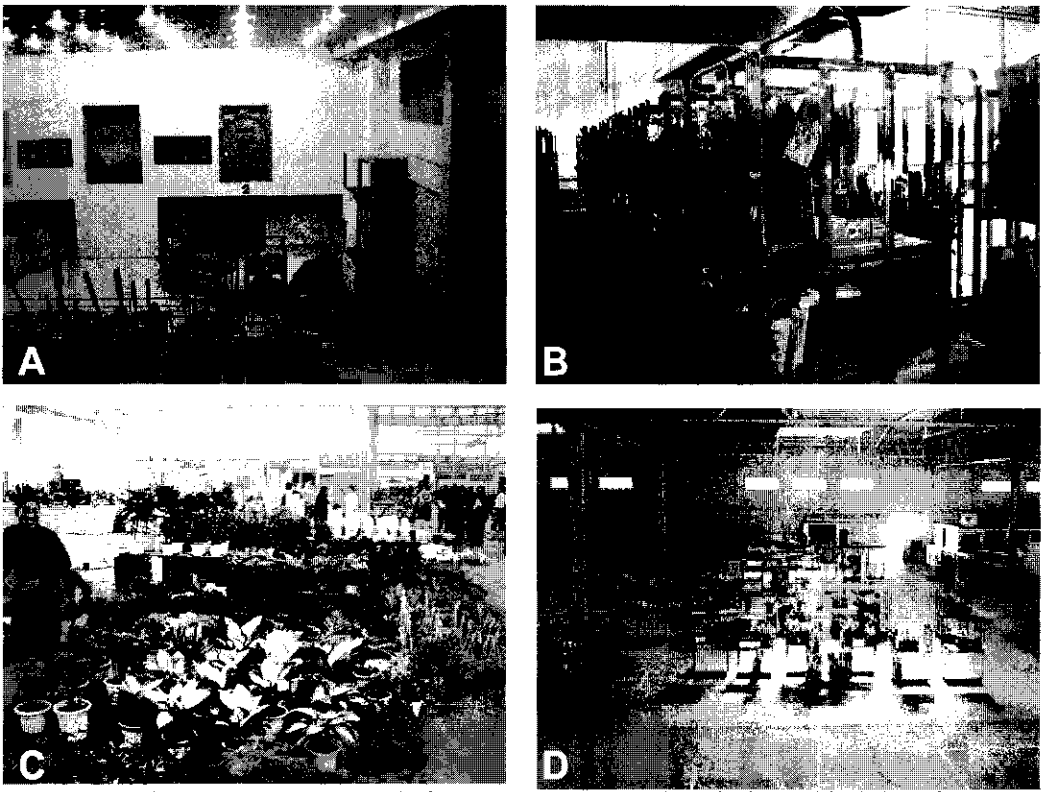

Fig. 7.6: (A) The *Kunming International Flora Auction* (KIFA) and **(B)** its internal logistics; **(C)** *Dounan Wholesale Flower Market* and **(D)** KIFA distribution floor.

7.3.2 Logistics

The post-harvest chain is far from optimised. Trucks are usually not cooled, even when necessary to transport floricultural products over large distances. Yunnan is far from the major consumer markets within China (Table 7.1). Moreover, the Kunming Airport does not have many direct flights to international floricultural markets, air freight of flower cargo is expensive and most of the time not possible. Most of the flowers are first transported by truck to Hong Kong Airport for further air cargo transport to the final customers. This ride takes 36 hours (1,456 km) and roads and product climate environment are often far from optimal. Packing of floricultural products is also not optimal.

Yunnan is strongly investing in road infrastructures. By 2006 a highway will connect Kunming to Bangkok. The highway will pass through Laos and the project will be fully financed by Chinese government. The 1,200 km distance will take 24 hours by truck. Besides faster transport, Bangkok offers other international flight options. Through that, Yunnan will be able to supply new markets. Also a new airport in Kunming with better cargo facilities is supposed to be ready in 2008 and should make it possible for Yunnan to attract more international business.

Table 7.1: Distance (km) from Kunming to main consumer areas (Keijzer, 2003).

Hong Kong	Shanghai	Beijing	Guangzhou
1456	3962	4329	1390

7.4 Research, Education and information sources

Yunnan Agricultural University (YAU, http://www.ynau.edu.cn) was established in Kunming in 1938. The University developed as a key university of Yunnan Province since 1993. In 2001, YAU became one of the two biological science experts training bases in Yunnan. The university is divided into 15 schools, most of them in the field of life sciences (e.g. gardening and horticulture, plant protection). The university has at this moment almost 6,700 students. The number is rapidly expanding as graduate programs are increasing. The school of gardening and horticulture has a staff of 75 people and presently 600 students. The school is divided in three departments; tea science, horticulture and gardening. This school has set up an exchange program with the university of professional education *Larenstein* in The Netherlands. Due to that, many students will follow part of their studies in Holland. The school strongly contributes to the economic and social development of Yunnan Province by training numerous professionals at different levels.

The *Kunming Institute of Botany* (KIB, http://www.kib.ac.cn), part of the *Chinese Academy of Science* (CAS), is involved in multidisciplinary research on the biodiversity and bioresources. This institute is also involved in the sustainable development of wild medicinal plants and potential ornamentals. Another relevant institute from CAS is the *Kunming Vegetable Research Institute* which is involved in the research and industrialise use of wild flowers (Peoplesdaily.com.cn, 2000).

Although many YAU graduates occupy positions on governmental or private farms, the interaction between the university and the growers seems limited. There is a limited extension service from the university to put scientific and technological achievements into practice and the growers (mainly the large) get most of their information from the supplying companies. There is a general need for more objective advice. The private companies can also hire experienced technicians, sometimes from abroad (e.g. from India) and consultants to get *state-of-the-art* information. Also their (international) suppliers and customers supply information.

7.5 Politics

The goal of the provincial government is to make the Yunnan floricultural industry export-oriented, specialized, high-tech, scientific, multi-channel, stock market-registered sector. This means that the local government will invest in providing a better business environment regarding flower growing, transport, marketing, training and research, investment capital, regulations and taxation, customs, quarantine, insurance and other related aspects.

To boost the development in Yunnan, the state council has granted further tax incentives to foreign invested enterprises (FIEs). Under the existing policy, FIEs are entitled to a three year tax reduction and exemption. The tax rate can be reduced to 10% if an enterprise is proved to export

more than 70% of its annual output in terms of value (GC.comm, 2002). This in part may justify why the greenhouse horticulture sector is among the sectors that receive more foreign direct investment in the province (NBSO, 2003).

7.6 SWOT analysis for the greenhouse horticultural sector in Yunnan

7.6.1 Strengths

- Cheap and enough labour
- Good climate (mild climate all year round)
- Availability of land and water
- Government is promoting/investing
- International attitude
- Biodiversity

7.6.2 Weaknesses

- Infrastructure (however improving)
- Know how / education
- Applied research backbone
- Extension
- Not much co-operation in marketing to benefit from economies of scale

- Not much co-operation between farmers
- Small local market (low income and low population density)

7.6.3 Opportunities

- Developing new floricultural crops
- Become new world supplier of ornamental crops
- Re-designing marketing, commerce and logistics
- Enforcing plant breeders rights
- Auction

7.6.4 Threats

- Bureaucracy
- Unfair competition between private and (semi) governmental companies
- Not fast enough obliging to international trade standards

8.

Overall analysis for the greenhouse horticultural sector in China

By Niek Botden and J. Miguel Costa

Abstract

In a huge and heterogeneous country like China one can expect that provinces differ in their suitability and future prospects for the greenhouse horticultural sector. The aim of this paper is to provide an overview and analysis of the situation and future prospects of the greenhouse horticultural sector in each of the five regions visited. The qualitative analysis of the five regions based on the strengths, weaknesses, opportunities and threats (SWOT) defined in previous chapters for each province is made more quantitative by scoring each region on the basis of a predefined set of horticultural performance indicators, This set of indicators include: 1) natural conditions (climate, water, soil), 2) infrastructure (roads, railway, airport), 3) labor (availability, costs, know-how of the management and employees), 4) logistics (distances, transports), 5) politics (legislation, incentives, bureaucracy, land price and availability), 6) auxiliary industry (e.g. agrochemicals or plastic), 7) marketing and commerce and 8) research and education (English language, technical skills, research and extension). The future prospects for greenhouse horticulture in each of the five provinces are mentioned.

8.1 Introduction

In a country like China, with a territory of 9.6 million km^2, which is about the size of the European continent, it is expected that provinces separated by thousands of kilometers differ in terms of their suitability and future prospects regarding the greenhouse horticultural sector. Natural conditions like climate and soils are diverse, but other factors like distance to main markets can be also determinants for success of the greenhouse horticultural sector.

The previous chapters reported the current situation of the greenhouse horticulture sector for the individual analyzed regions. In this chapter all that information is integrated and further analysed. A comparative qualitative and quantitative score-card analysis of the five analyzed provinces is conducted. SWOT-analyzing techniques used to define the strengths and weaknesses of each province/municipality when analyzing its horticultural potential performance indicators (see 8.3.1).

The set of the indicators include parameters which have been assumed relevant to characterize, classify and further compare the 5 horticultural regions in comparing their current situation and future prospects for greenhouse horticultural business. Finally this chapter evaluates China as a whole regarding the situation and future prospects in relation to the outside world and foreign competitors. For this comparison, we used the Netherlands as reference, because its horticultural system is well characterized and described and is well known worldwide

8.2 Qualitative evaluation of the five regions by a SWOT analysis

The following tables provide the overall resume of all the individual SWOT analyses presented in the previous chapters. In the next paragraph this SWOT and the information reported in the literature review brought in Chapter 2, as well as the detailed information contained in Chapters 3 to 7 extended with impressions of the team is then quantitatively converted into horticultural potential performance indicators in score-cards for further analyzing.

Table 8.1: Qualitative SWOT-analysis (part 1)

Region	Strengths	Weaknesses	Opportunities	Threats
Beijing	• Large, high income domestic market (market for high quality product) • Transport infrastructures (roads, airport) • Know-how to grow pot plants (bromelia) • More international business environment (many international contacts and more international minded) • Close location of research centres (CAAS and CAU)	• Urbanisation pressure • Higher labour costs compared to other horticultural provinces (e.g. Shandong) • Lack of know-how in crop management (e.g tomato diseases are one of the big constraints in tomato production (Ma et al., 2000)	• Increasing domestic consumption in pot plants • Faster rate of modernisation compared to other provinces • Low production costs (compared to other foreign producing countries) • Easy contact with foreign markets (Japan, South Korea, Malaysia) • Increased concern with pesticide residues and demand for higher quality • High GDP per capita and growth of the tourism activities will increase the demand for higher quality products	• Lack of good quality water (Wolf et al., 2003) • Increased production in other provinces • Oversupply and low prices • Management (lack of know how, bureaucracy, hierarchical system, limited efficiency of the extension system)
Shanghai	• Large domestic market, better educated consumers and elite market • Good transport infrastructures (good roads, harbour, airport) (much better than other provinces; Shanghai has the largest harbour of China) • High quality of pot plant production (e.g. bromelia) • Know-how available (more technicians, sources of information and mechanisation available comparatively with other provinces)	• Urbanisation pressure • Higher labour costs compared to Shandong and Yunnan • Weather conditions for cut flowers (high temperatures and high relative humidity in summer) not so good as in Yunnan • High competition among new companies	• Increasing domestic consumption in pot plants (intern market) • Low production costs (compared to foreign producers) (export market) • Easy contact with the foreign markets (Japan, Hong Kong, Taiwan) (export market) • Increased concern with pesticide residues and demand for higher quality • High GDP per capita and growth of the hotel and restaurants sector will increase demand for higher quality products	• Increased production in other provinces • Greenhouse vegetables can be produced cheaper elsewhere • Oversupply and low prices • Increased production costs (e.g. labour)

Table 8.1: Qualitative SWOT-analysis (part 2)

Province	Strengths	Weaknesses	Opportunities	Threats
Jiangsu	• Highly populated (large provincial market) • Good location (proximity to large markets, both local market and Shanghai municipality) • Large transport infrastructures (good transport network in terms of highways, trains and vessel) • Proximity to the agrochemical industry • Long tradition in vegetable production • Largest area of ornamental production • High quality of bonsai and anthurium production	• Language: very limited number of managers that speak English (many visit cards and brochures only available in Chinese) • Low productivity of vegetable production (even in the high-tech greenhouses) • Lack of specialisation (growers produce a large range of products, specially in pot plant sector) • Low know-how on crop management and pest and disease control • Low water use efficiency (furrow irrigation, open water transport channels, uncovered water reservoirs) • Lack of co-operation among growers	• Province with relatively high average income (opportunity for high quality products) • Increase in the volume of supermarkets' sales (where high quality vegetables are better paid)	• Competition with other provinces (mainly with Shandong in vegetable production and Yunnan in cut flower production) • Strong governmental interference in company and production planning • Water quantity and quality (EC level of the water might increase due to high fertilisation levels and absence of closed ferti-irrigation systems) • High population density (pressure on the land for construction and industry)
Shandong	• Concentrates large area of greenhouses and horticultural suppliers (fertilisers, seeds, plastics) (cluster) • Large wholesale market for vegetables • More open to purchase of foreign seeds compared to other provinces • Labour costs lower than other provinces or municipalities (e.g. Beijing, Shanghai) • Tradition in production and commerce on vegetables • Transport infrastructures (improved road network, sea harbours e.g. Qingdao) • Relatively close to major consumer centres	• Limited investment possibilities / Many small companies • Quality of the product (packing, grading, quality control) • No refrigerated transport • Deficient logistics • Limitations in the use of English	• Low wages • Preferential relation with Beijing ("Green Channel" for vegetables) • Increased demand for vegetables in other provinces	• Increased competition from other typical vegetable producing provinces (e.g. Jiangsu) • Market has low prices (over supply and saturation) • Lack of market information (low profit for growers)

Table 8.1: Qualitative SWOT-analysis (part 3)

Province	Strengths	Weaknesses	Opportunities	Threats
Yunnan	• Cheap and enough labour • Good climate (mild climate all year round) • Availability of land and water • Government is promoting/investing • International attitude • Biodiversity	• Infrastructure (however improving) • Know how / education • Applied research backbone • Extension • Not much cooperation in marketing to benefit from economies of scale • Not much cooperation between farmers • Small local market (low income and low population density)	• Developing new floricultural crops • Become new world supplier of ornamental crops • Redesigning marketing, commerce and logistics • Enforcing plant breeders rights • Auction	• Bureaucracy • Unfair competition between private and (semi) governmental companies • Not fast enough obliging international trade standards

8.3 Quantitative score-card SWOT-analysis for the horticultural performance indicators

A set of horticultural potential performance indicators is used to quantitatively evaluate each of the five regions regarding the greenhouse horticultural sector. The set of potential performance indicators considered is:

1) Natural conditions (climate, water, soil)
2) Infrastructures (roads, irrigation, etc)
3) Labor (availability, costs, level of education and know how of workers and management staff)
4) Logistics (distances, transports, cooling-chain)
5) Politics (legislation, incentives, bureaucracy, land price and availability)
6) Agricultural industry (agrochemical use and availability)
7) Marketing and commerce
8) Research and education (education level of farmers and managers, English language skills, technical skills, research and extension)

Each factor has been scored according to a 1 to 5 scale where:

1 = very negative
2 = moderately negative
3 = neutral
4 = moderately positive
5 = very positive

8.3.1 Quantitative score card SWOT analysis

The quantitative score card for the horticultural potential performance indicators for the analyzed provinces is presented in Table 8.2. The potential of The Netherlands was also scored according to the same performance indicators. This makes it is easier for readers to compare other countries with China, as Dutch greenhouse horticulture is very well quantified by statistics and literature and is thus world wide well-known. In the last column also a suggested weight for the horticultural potential performance sub-indicator is presented which will be used to obtain one value for each main indicator. This method will finally generate an overall score for the provinces.

One should keep in mind that the relative weight of the main and sub-indicators can vary according to the interests and aims of the evaluator. For example, the relative importance of the indicators can differ according to the business sector. Hence, it is expected that the seed sector would give much more weight to the politics for breeder's rights. When needed, the reader can easily change the weight of the score, which may result in another final outcome.

Table 8.2: Absolute quantitative score card SWOT analysis

Horticultural Potential Performance indicators	Horticultural Potential Performance sub-Indicator	Beijing	Jiangsu	Shangdong	Shanghai	Yunnan	The Netherlands	Weight of indicator
Natural resources	Climate (radiation)	4	4	4	4	4	3,5	25%
	Climate (temperature in winter)	1	2	2	3	4	4	10%
	Climate (temperature in summer)	2	3	3	4	4	4	10%
	Climate (RH)	3	2	3	4	4	4	10%
	Water availability	1,5	3,5	3	1	5	5	20%
	Water quality	2	3	2	3	5	4,5	10%
	Land availability	2	2	3,5	2	5	2,5	10%
	Natural biodiversity	2	2	2	3	5	2	5%
Labour	Management skills	2,5	2,5	2	2	2	5	20%
	Availability (own province labour)	5	5	5	5	5	3	15%
	Labour costs	3	3	4	3	5	1	25%
	Labour education level	3	2	2	3	2	5	15%
	Labour productivity	2	2	2	2	2	5	20%
	English speaking	1	1	1	1	1	5	5%
Economics	GDP per capita	3	3	2	3	1	5	75%
	Access to loans (banks)	3	2	2	3	2	5	
	Land costs	3	4	5	3	5	1	25%
Auxilary Industry	Pesticide/fertilizer/plastics availability	4	3	3	4	2,5	5	
	Pesticide/fertilizer/plastics quality control	3	2	2	3	2	5	100%

Table 8.2: Absolute quantitative score card SWOT analysis (continued)

Horticultural Potential Performance indicators	Horticultural Potential Performance sub-Indicator	Beijing	Jiangsu	Shangdong	Shanghai	Yunnan	The Netherlands	Weight of indicator
Production system	Costs of greenhouse structure	4	4	4	4	5	1	7,5%
	Scale of individual farms	1	1	1	2	1	5	12,5%
	Many suppliers of greenhouses?	4	4	4	3	3	5	5%
	Heating needs	1	2	1	3	4	1	10%
	Soilless culture needed / used?	2	2	1	2	1	5	5%
	Active Heating needed for winter production? (high score = no need)	3	1	1	4	5	4	12,5%
	Active Cooling needed for summer production? (high score = no need)	4	3	3	4	4	5	12,5%
	Information exchange in between growers	2	2	2	2	2	5	10%
	Automization rate to optimize processes	2	1	1	2	2	5	15%
	Technical support / extension	3	2	2	3	2	5	10%
Politics	Governmental motivation in Horticulture	4	4	4	5	5	2,5	35%
	Plant protection enforcement (UPOV2)	2	2	2	2	2	5	20%
	Foreign investments	4	4	4	4	3	1	25%
	Provincial Finance resources for horticultural investments	4	4	4	5	3	2,5	20%
Logistics and infrastructure	Distance to domestic market	5	5	4	4	1	5	25%
	Distance to export market	5	4	3	5	3	5	35%
	By truck	4	2	2	4	1	5	20%
	By train	3	3	3	3	2	5	5%
	By plane	5	4	4	5	3	5	15%
Marketing	Market information	3	2	2	3	3	5	10%
	International business focus	3	3	3	2	3	5	15%
	Competition between companies (high score is low competition)	3	3	3	3	4	1	15%
	Market driven production	2	1,5	1	2	3	5	10%
	Specialisation	2	1	1	3	3	5	10%
	Big local market?	5	4	3	5	2	2	15%
	Added value driven market?	3	1	1	3	2	5	3%
	Cooparatives acitve?	3	2	2	2,5	3	5	8%
	Auctioning sales?	2	0	0	0	3	5	5%
	Intermidate sales? (B2B)	4	4	4	4	4	5	5%
	Direct sales? (B2C)	3,5	3,5	3,5	3,5	3,5	2	5%
Research and education	Environmental concern (heathy food)	2	3	2	2	2	5	20%
	Tradition in greenhouse horticulture	3	3	3	3	2	5	35%
	Research and education available	4	3	3	4	2	5	30%
	English speaking	1,5	1,5	1,5	1,5	1,5	5	15%

8.3.2 Relative sub-quantitative score card SWOT analysis

The scores in table 8.3 for the main indicators are the weighed sums of the sub-indicators (Table 8.2). Assuming that the main performance indicators are equally important in the overall score for a region, the summarized score is shown as the non-weighed sum in Table 8.3. Also a weighed sum has been calculated, based on the weights proposed in the last column of Table 8.2. It is e.g. assumed that natural resources (weight = 15%) are more important in a region for its horticultural performance than the presence of auxiliary industry (weight = 7.5%).

Table 8.3: Sub-relative quantitative score card SWOT analysis

Horticultural Potential Performance indicators	**Beijing**	**Jiangsu**	**Shangdong**	**Shanghai**	**Yunnan**	**Holland**	**Weight indicator**
Natural resources	2,4	3,0	3,1	3,2	4,5	3,9	15,0%
Production system	2,5	2,0	1,8	2,9	2,9	4,2	12,5%
Labour	2,9	2,8	2,9	3,3	3,2	3,7	12,5%
Logistics and infrastructure	4,7	3,8	3,2	4,5	2,1	5,0	10,0%
Marketing	3,1	2,5	2,3	2,9	3,1	3,8	10,0%
Economics	3,8	4,0	3,5	3,0	2,0	4,0	7,5%
Politics	3,6	3,6	3,6	4,2	3,5	2,6	15,0%
Auxilary Industry	3,0	2,0	2,0	3,0	2,0	5,0	7,5%
Research and education	2,9	2,8	2,6	2,9	1,9	5,0	10,0%
Non-weighed sum	**28,9**	**26,4**	**25,0**	**29,8**	**25,1**	**37,2**	**100,0%**
Weighed sum	**3,2**	**2,9**	**2,8**	**3,4**	**3,0**	**4,0**	

Both the non-weighed and weighed sum lead to the conclusion that Shanghai and Beijing are the regions with the highest horticultural potential performance within China. However, that potential is clearly below that of The Netherlands. Shandong, Jiangsu and Yunnan have a somewhat lower horticultural potential than Beijing and Shanghai and hardly differ from each other.

It should be noticed that main indicators can be weighed differently accordingly the evaluator's interest. This may lead to other conclusions. For example, Yunnan has a high score for natural resources. If we were to give that indicator a dominant weight in the overall score (e.g. 50%) it is likely that Yunnan gets the highest overall score.When analyzing daily practice in a (part of a) region it is well possible that observations do not always agree with the potential performance scores in this chapter. This may be caused by heterogeneity within regions, or by the fact that a potential is not always reached. Furthermore, the potential performance indicators are not fixed since they are build up by sub-factors that are partly dynamic and can change quite easily since e.g. markets and politics can change.

When certain factors are more important for certain crops than for others, this may explain why certain regions are major suppliers for certain crops. For example, for cut flower production both climate and production methods are very important. As it is quite easy to transport volume, Yunnan is expected to remain competitive and one of the best provinces regarding the production of cut flowers (Table 8.3). For pot plant production the proximity to the major markets (big cities) is very important to keep transportation costs low. This is why Shanghai is likely to become a specialized greenhouse pot-plant production area, benefiting also from the suitable climate and know-how for pot plant production.

For vegetable production, keeping transportation costs low is relevant, because cargo weight and volume is often high and the added value that can be created in the vegetable chain is lower than for ornamentals. Therefore, it seems logic that vegetable production takes place in Shangdong and Jiangsu, in the middle of two major markets, and Jiangsu benefiting from a large provincial market.

8.4 Future prospects for the provinces/municipalities

8.4.1 Beijing and Shanghai

Together with Guangzhou province these two municipalities are expected to keep their leading position regarding consumption of vegetables and fruits as well as of ornamental products like cut flowers, pot plants and garden plants. A fast increase in market demand for high quality vegetables and flowers is expected for these two municipalities. The local horticulture is probably threatened by the pressure on the land (construction and industry) and by the higher production costs. Labor costs are higher than in other provinces. Furthermore, it is likely that improvements in the transport infrastructures make it easier to transport products from other provinces to the big cities.

Consequently on the medium-long term Shanghai's position as vegetable producer will be weakened. In turn, pot plant production in Shanghai is expected to remain competitive as the quality of the products seems good and there is know-how available to produce these crops. Because of the positive attitude of the local government concerning horticulture, it might be easier to get enough funding to cope with higher investments needed for pot-plant production. The international contacts of the municipality and the availability of infrastructure like the airport and the harbor may facilitate the expansion of the sector via exports.

Shanghai cut-flower production has to compete with specialized cut flower's production areas such as Yunnan. Weather conditions mainly in the summer are not optimal for cut flower production. Due to higher cost price of production when compared with for example Yunnan, low market prices will shift the cut flower sector towards better suitable regions as Yunnan. Therefore, the cut flower sector is expected to find limitations in Shanghai.

8.4.2 Shandong and Jiangsu

Comparing these two major producers of vegetables in China we may state that Shandong can be possibly more competitive. Shandong is expected to remain competitive in greenhouse vegetable production resulting from its strong current position in both production and market (see Chapter 6). Shandong has the largest production area, is close to the auxiliary industry (seeds, plastics, fertilizers) and has good contacts with the other provinces and municipalities in commercial terms (The Shouguang Market is one of the largest vegetable markets). It has a long tradition of supplying vegetables to big cities like Beijing (the "Green Channel") and Shanghai. Shandong will keep also very strong in the fruit production both in open field as well as in greenhouses. Seed production can be one of the future developments of this province based on the good climate conditions and the presence of several seed companies in the province.

Jiangsu, just like Shandong, is an important vegetable producing and exporting province. Vegetables from Shandong compete with Jiangsu production. However, Jiangsu has the largest area of ornamental production in China, especially ornamental trees. This sector has good perspectives because of the increasing demand for ornamental plants for gardens. Jiangsu will remain one of the largest vegetable producers but the tendency will be for a shift towards more profitable crops like ornamentals. Jiangsu has also a good internal market as it has one of the highest populations and one of the highest GDP's per capita. Because of this, sales of more exclusive crops as pot plants are possible instead of production of only primary life necessities. Jiangsu is also quite open to foreign investment and since it has a rather good geographical location, it can benefit from exports overland, sea and by airplane.

A big constraint in the North part of China will be the scarcity of good quality water. It is possible that measures taken by the government to solve the water problems will limit the negative consequences and can avoid future problems for the greenhouse horticulture sector or for the sector of seed production in the area.

8.4.3 Yunnan

Yunnan has effectively optimal climate conditions for both ornamentals and vegetables. It is certainly the most important province producing cut flowers and starting material for ornamental crops (NBSO, 2003; Jiang et al., 2004). However, it faces the major problem of large distances from the consumer centres in China and abroad as well as the associated high transport costs. This is a major weakness of the region and a possible threat if there is no improvement in the road or air connections to other parts of China. Other weakness is the fact of having low population density (small and low segment local market) as it is one of the provinces with the lowest GDP per capita (See Chapter 7). The new flower auction system is a challenge for the horticulture in the province.

8.5 Considerations for China as a whole

8.5.1 Natural conditions and environment

China faces a dramatic problem of limited land and water resources. The Chinese population is still growing and will stabilize only in 2030 at a size of 1.6 billion (Sun Zhong-Fu, pers.comm.). China has about 1/4 of the per capita world average water and about 1/3 of the per capita world average tillable land (Chapter 2). In 2010 the per capita amount of tillable land is expected to have declined by 50%, because of increased land use for houses, industry and transport infrastructure and population growth. Also the water resources per capita are expected to decrease by about 50%. To make this situation worse, water use efficiency is low due to insufficiently maintained irrigation structures and the common use of furrow irrigation both in open field cultivation and in greenhouses. Soil and water pollution due to the use of agrichemicals in open systems and soil erosion and salinity are other major problems.

There is an increasing concern among Chinese consumers (mostly from the big cities) about health and risks of pesticide use. Because of this the Chinese government adopted more strict regulations for pesticide and fertilizer use in horticulture. Simultaneously, there is an increasing demand for organic fruits and vegetables on the internal as well as the international markets, which explains the expansion of organic production in China.

8.5.2 Labour

China has plenty of labor available and at low cost (Chapter 2). However, there are also limitations regarding the technical skills of farmers and their education level. This is a limitation for the development of the sector. It limits the use of more technical greenhouses or at least the efficient use of these greenhouses in China. The acceptance of new growing practices and pesticide use is also related with that.

8.5.3 Property and production structure

In general two major types of companies can be found in China: large scale operations belonging to the government or private investors and small-scale family farms. The second group represents by far the largest part of the companies in China. In this case the size of the property is excessively small and results in small-scale production, low productivity and efficiency and difficulties for the agricultural extension services and law enforcement. This situation could be addressed in all the visited provinces and municipalities and is not expected to change on the short term because until now it has also guaranteed employment and social stability in rural zones (Weimin, 2001).

The production on large-scale companies has a great limitation due to the management and also the lack of know-how. Many times the ultimate decision is not taken by the technical staff but rather by some one hierarchically higher (communistic party member) and not directly related with the production. Moreover, the investment costs of the large state-owned companies are not taken into account. Hence these companies are assumed to be profitable although the government injects money into it. This creates an artificial structure of costs and generates unfair competition with real private companies.

8.5.4 Logistics

Logistics are still one of the weaknesses of the Chinese greenhouse horticulture. Although the changes in transport infrastructure have been large, especially in the last 5-10 years there is still place for optimization and increase in efficiency. The "more rural" China, like the inner parts of Shandong, Jiangsu and Yunnan, still needs a lot of improvement in infrastructure. Optimizing post-harvest handling to keep product quality as high as possible should be one of the major goals since losses in the chain are huge.

8.5.5 Marketing and quality

There is in general a lack of quality in the horticultural production chain according to international standard levels. This mainly results from a lack of technical know-how that has negatively effects both on production and post harvest phases of the supply chain. The average Chinese customer is price sensitive rather then quality sensitive. However, the demand for quality is increasing in the big cities like Beijing and Shanghai and other provincial capitals.

8.5.6 Research and innovation

The availability of know-how regarding greenhouse cultivation seemed larger in the big cities where the information is more spread due to the activity of the research institutes or due to the higher efficiency of the extension services. Moreover, the provinces already grow vegetables in greenhouses for several years and it is possible that some more years of experience and investment in better greenhouse structures can improve yields and quality. Positive is the fact that the university sector is very open to the outside world. However, the language is still a big limitation, as many researchers are not able to communicate in English.

8.6 Theoretical framework and strategy future development of Chinese horticultural sector

8.6.1 Introduction

The Chinese horticulture is in the growth stage, supplying a simple product portfolio in straightforward marketing channels. Little is known about the Chinese consumer behaviour,

attitudes and awareness besides the sensitivity to local produce. Both economic and institutional trends in Chinese horticulture are related: step-by-step institutional reforms. New reforms are expected, following the experimental special economic zones. Access to WTO will guide liberalization and integration in the world economy. One example is the explicit addition of protection of property rights to the constitution (March 2004), where until now all production factors where state-owned.

As stated before, it is not easy to create a consistent and objective framework to describe according to which factors the Chinese horticultural sector will develop. However, this paragraph tries to create a certain framework with maximum and minimum boundaries. Within this framework, the horticultural future of China can develop in the near future. This model is published by Keijzer (2003).

8.6.2 Theoretical framework

Keijzer (2003) developed three possible scenario's for the Chinese horticultural sector with special attention towards the floricultural sector. These scenario's are:

- Capitalistic scenario
- Bleak scenario
- China web scenario

The *capitalistic scenario* foresees trade liberalisation and an enhanced institutional environment. The logical mode of entry for foreign companies is by direct investments in the horticultural sector of China as soon as possible with the most commitment and risk. At the moment this is only possible in the special economic zones.

The *bleak scenario* foresees negative aspects of fast economic development and changing institutional environments. The scenario boundaries are corruption, damage of the environment and social unrest. The logical mode of entry for foreign companies is by contracting. This is already the most chosen option in the Shanghai area to avoid risks and commitment

The *China web scenario* foresees an own development of the horticultural sector in order to fulfil the demand for local produce. The logical mode of entry for foreign companies is by building relationships with Chinese actors in the value chains by creating joint ventures.

8.6.3 Usage of scenarios

The dominant capitalistic scenario is the most prosperous scenario. The horticultural supply chain develops into a complete industry with enhanced technology and fierce competition. The focus should be large-scale production and distribution to fulfil market demands. When planning to become active in China, a company could base its strategy on the capitalistic scenario as this is the dominant one. The other two scenarios can only influence the capitalistic scenario to some extent.

In order to see how relevant all factors of a certain scenario are, new research is needed to define a set of early indicators of coming-up big changes defining relevance and importance of a certain scenario. With this, one can continuously describe one's position inside the framework of the scenarios which makes it possible to define strategy pathways which should be followed to achieve the point where achieved horticultural performance is the maximum achievable regarding earlier stated horticultural potential performance indicators.

By conducting cross-SWOT analysis by using previous chapters, it is possible by crossing strengths and opportunities to define possible short-term success areas for the fields of interest of the reader. By crossing strengths and threats, it will be possible to define areas of future development for one's own goals of interest in Chinese horticultural sector. By crossing weaknesses with opportunities, one can fulfil this area after taking the changes coming out of the crossing of strengths and opportunities. When crossing the weaknesses with the threats, one can define areas where one should not focus at all for future developments.

When creating the set of early indicators to allocate the position inside the framework of scenarios (external) combined with the strategy goals coming from the cross-SWOT analysis (internal), a new combined strategy is defined. To achieve potential performance of this combined strategy, it is needed to optimize following factors (internal) till reaching its potential:

- Do things cheaply (Cost advantage)
- Change what you do (Responsiveness or flexibility advantage)
- Do things quickly (Speed advantage)
- Do things on time (Dependability advantage)
- Do things right (Quality advantage)

When on all of these points maximum performance is achieved, you will possible achieve potential performance for the horticultural performance indicators as reported before.

References

Acess Limited (2000). Fresh flowers and Plants in China: A market analysis.

http://www.chinaonline.com/estore/Consumer_Goods/AA030-30_sample1.pdf

Access to Asian Vegetables (2003). Limiting limp leafys, Issue 57, March 2003. http://www.nre.vic.gov.au/trade/asiaveg/aav-nl-57-2003-mar.pdf

Aden N and Herzfelder R (2002). China Peoples Republic: Market development reports, the repining of China's Food processing sector. USDA Foreign Agricultural Service, Gain Report, March 2002. http://www.fas.usda.gov/gainfiles/200204/135683912.pdf

Aden N and Moutouraski P (2002). China Peoples Republic: Exporter Guide Annual 2002. USDA Gain Report , August 2002.

http://www.fas.usda.gov/gainfiles/200211/145784566.pdf

Agjournal.com (2001). China more open to seed trade.

http://www.agjournal.com/story.cfm?story_id=1673

Agrifood-Canada (2002). The horticultural products market in China, September 2002, Market information Asia Pacific. http://atn-riae.agr.ca/info/asia/e3382.htm

Agriholland (2003). Nederlandse expertise helpt Chinese tuinbouw van de grond. Haagsche Courant/ SIDHOC. http://www.agriholland.nl/nieuws/home.html

AIPH (2003). *International Statistics Flowers and Plants - 2002, Statistical Yearbook.* Zoetermeer, The Netherlands: International Association of Horticultural Producers (http://www.aiph.org/uk/index.html).

Anonymous (2002a). Japan increase imports from China where trade is thriving. *FlowerTech,* vol.5 n.7, p. 5

Anonymous (2002b). China flower industry developing rapidly. *Horticultural Industry*, pp 42-43.

Anonymous (2002c). The market for winter vegetables in China: a wealth creation opportunity for smallholders.

Anonymous (2003a). Hortiflorexpo China. Largest Horticulture trade fair in China. *Greenbusiness International*, 1: 64-65.

Anonymous (2003b). HighTech Ag in Morocco. *NewAG International*. September 2003. 42-60.

Bakker JC and Challa H (1995). Aim and approach of this book. In: Bakker JC, Bot GPA, Challa H and Van de Braak NJ (Eds). *Greenhouse climate control. An integrated approach.* Wageningen Pers, Wageningen, The Netherlands, pp. 1-3.

Baoming L and Qiang P (1999). Development of greenhouse technology in China. Proc. 99 Int. Agric. Engineering, Beijing, China. pp. 30-33.

http://www.lib.ksu.edu/depts/issa/china/icae/part3/be30.pdf

Bartholomew H (1994). The world's largest extension system. *Journal International Agricultural Extension and Education* Spring 1994, pp 32-36.

Bean CE and Branson A (2003). China Peoples Republic. Asparagus Situation 2003 GAIN Report, December 2003. http://www.fas.usda.gov/gainfiles/200401/146085565.pdf

Bent E (2001). China: Much cheaper by rail. *Floraculture International* June 2001. p.10.

Bent E (2002). Rationalising production in China. *Fruit&VegTech*, vol. 2, 2: 6-7.

Bent E (2003). China: Development of bio-diversity. *Floraculture International*, February 2003, p. 11.

Bent L (2000). China: First trial auction sets precedent for success. *Floraculture International*, February. .p. 9.

Bent L (2002). China: Agri-projects and a challenging economy. *Floraculture International*, September 2002, pp. 62.

Bolen W P (1997). Perlite.

http://minerals.er.usgs.gov/minerals/pubs/commodity/perlite/520497.pdf

Brandrecon.com (2002). Wages and tools in China.

http://www.brandrecon.com/sr08062002.htm

Branson A and Qing X (2001). China Peoples Republic. Planting Seeds, Seed Law Implementation Regulations 2001. USDA Foreign Agriculture Service Gain Report April 2001. http://www.fas.usda.gov/gainfiles/200104/70680391.pdf.

Bristish Colombia Ministry of Agriculture (2003). An overview of the BC Greenhouse Vegetable Industry. November 2003, 11 pp.

http://www.agf.gov.bc.ca/ghvegetable/publications/documents/industry_profile.pdf

Burke B and Wingard C (1998). The big chill.

http://www.chinabusinessreview.com/9707/wingard.html

Buurma JS (2001). Dutch agricultural development and its importance to China. Agricultural Economics Research Institute (LEI), The Hague, the Netherlands, 43 pp.

U.S. Commercial Service (2003). Business in Jiangsu at a Glance

http://www.buyusa.gov/china/en/cienp.html

CABTS (2003). China Agricultural Broadcast and Television School.

http://www.crdenet.net.cn/english.htm

Cantliffe D and Vansickle J (2003). Mexican competition: Now from the greenhouse. 2003 Tomato Institute, Florida, pp. 2-3. http://gcrec.ifas.ufl.edu/TOMATO%202003.pdf

Cao C and Suttmeier RP (2001). Research report: China's new scientific elite: distinguished young scientists, the research environment and hopes for Chinese Science. *The China Quarterly*, pp.960-984.

CBS (2003). *Statistiek jaarboek 2003*. Central Bureau voor de Statistiek, Den Haag, 559 pp.

CCICED (2002). Proposal for a New CCICED Task Force: Policy Responses to Non-point Pollution from China's Crop Production. China Council for International Co-operation on Environment and Development.

http://www.harbour.sfu.ca/dlam/Taskforce/nonpoint.html

Chang L (2002). The seeds of change. *Wall Street Journal*, October 14, 2002.

http://www.agobservatory.org/News/news.cfm?News_ID=1919

Chang-ji Z (2003). The structures and their performance of greenhouses in China. In: Abstracts Sino-Dutch Symposium on Modern Protected Horticultural Production, 28 October 2003, Beijing. p. 23.

Chen TY, Yamaguchi T Kuroyanagi T (2000). Energy saving sun light greenhouse in China. *J. Soc Agri Struc Japan*, 31(2):113-118.

Chen N, Gan Y, Wang G. (2003). Photosynthetic responses of muskmelon (*Cucumis melon* L.) to photon flux density, leaf temperature and CO_2 concentration. *Can. J. Plant Sci.* 83: 393-399. https://ginkgo.cisti.nrc.ca/ppv/RPViewDoc?_handler_=HandleInitialGet &journal=cjps&volume=83&articleFile=P02-124.pdf&secure=true

Chengwei M, Renjie D and Yamaguchi T (1999). Current situation and perspective of facility horticulture engineering technology in China.

http://www.lib.ksu.edu/depts/issa/china/icae/part3/be73.pdf

Cngreenhouse.com (2003). Notification of Reinforcing Management of Importing Greenhouses. Document of MOA No. 4 [1999]

http://www.cngreenhouse.com/englishversion/policy_1.htm

Cody S and Blenkinsopp D (2003). The fruit and vegetable industry in China. China briefing September 2003. http://www.china-briefing.com/chinabusiness/200309.pdf

Consulate General of Switzerland (2003). Current Economic Situation of the Yangtze Delta Region. Shanghai Flash (2003) Issue n° 1, March 2003.

http://www.sinoptic.ch/shanghaiflash/texts/pdf/200301_Shanghai.Flash.pdf

Costa JM (2003). Greenhouse Horticulture in China: situation and prospects. Preliminary report, April 2003. Horticultural Production Chains group. 79 pp.

Costa JM and Monteiro A (2003). Portugal's potential for commercial production. *FlowerTech* Vol. 6. n.6 . pp. 47-49, 51.

Costa JM, Heuvelink E, Botden N (2003). Chinese growth held in check. *Fruit&VegTech* Vol.3 n.3 pp. 12-15.

Crook FW (1997). Introduction to China's Horticultural Economy. ERS Report, June 1997, pp. 47-51.

Cui H (2003). Plasticulture in Asia. In: Abstracts Sino-Dutch Symposium on Modern Protected Horticultural Production, 28 October 2003, Beijing. p. 6.

Diamond JE (1999). Agro-Technical Education in China. *Journal of International Agricultural and Extension Education,* Fall 1999, 13-18.

Diankui C and Mingchi L (1998). An overlook at vegetable production, consumption, distribution and its progress in China. *Acta Horticulturae*, 467:33-41.

Diario Vasco (2002). Incoa instala invernaderos controlados in China. www.diariovasco.com/pg020924/prensa/noticias/ Economia/200209/ 24/DVA-ECO-344.html

Donovan J and Krissoff B (2001). Trade issues facing U.S. horticulture in the WTO negotiations. Electronic Outlook Report from the Economic Research Service, USDA, August 2001.

Dutch Horticultural Board-LNV (2002). *Overview of the floricultural sector of the P.R. of China.* Ministry van Landbouw, Natuur en Vissery and ProductschapTuinbouw, The Netherlands, 75 pp.

Fang X and Jingfen J (1997). Challenge and Countermeasure- Effects of plant biotechnology on China's seed industry. In: *Seed Industry and Agricultural Development. Chinese Association of agriculture Development*, Ministry of Agriculture China, China Seed Group Corporation (Eds), pp.24-29.

FAO (1994). Research on the temperature environment of solar greenhouse. http://www.fao.org/ docrep/ T4470E/t4470e0c.htm#TopOfPage.

FAO (2003) http://apps.fao.org/

FAS-USDA (2003). Yunnan Province.

http://www.fas.usda.gov/pecad/remote/china/yunnan.html.

Feng SQ (2001). Problems and counter measures in Post-harvest handling of fruits and vegetables in China. In: *Postharvest Handling of Fresh vegetables*. T. O' Hare, J. Bagshaw, W.Li, G. Johnson (Eds), ACIAR Proceedings 105, p. 8-11.

http://www.aciar.gov.au/web.nsf/doc/JFRN-5J47AM/$file/P105%20Chapter%201.pdf

Genesis Technological Group (2003). Water Crises in China 2003. http://www.genesis-technology.net/Genesis_water_crisis_paper.pdf

Gifford R, Junyang J and Branson A (2002). China Peoples Republic of Planting seeds Annual 2002. USDA Foreign Agricultural Service Gain Report, May 2002 http://www.fas.usda.gov/gainfiles/200212/145784822.pdf.

Girardet H (2002). Urban agriculture and sustainable urban development. 8 pp.

http://www.agsci.kvl.dk/njf327/papers/reviewed.Girardet.pdf

Guisheng W, Jun T, Shulin G (2003). Innovation system and transformation of the Agricultural Sector in China with the case of Shouguang city. School of Economics and management, Tsinghua University, Beijing.

http://www.sinal.redesist.ie.ufrj.br/globelics/pdfs/GLOBELICS_0087_WU.pdf.

GTZ (2001). Metil Bromide Action in China. May 2001, n.2. German Agency for Techical Cooperation. http://www.gtz.de/proklima/doc/newsletters/mb_china_2.pdf

Gulobkov D (2003). Evolution of the NPK market in China. 2003 IFA Regional Conference for Asia and the Pacific, Republic of Koream October 2003.

http://www.fertilizer.org/ifa/publicat/PDF/2003_regional_cheju_golubkov.pdf

Haines B (1998). China´s Economic Awakening. *FloraCulture International*. September 1998, 39-40.

Han S (1997). Organic farming-growing plants the organic way. In: *Feeding a billion. Frontiers of Chinese Agriculture*. Wittewer S., Yu Y, Sun Han, Wang Lianzheng (Eds). Michigan State University Press. pp. 111-125.

Hamburguer J (2001). Sea of pesticides surrounds China´s organic farms. Global Pesticide Campaigner, Vol.11, n. 3, December 2001.

http://www.panna.org/resources/gpc/gpc_200112.11.3.04.dv.html

Hang C. (2000). A brief introduction of International co-operation in China. Acta Horticulturae, 524:255-260.

Huang SW (2002). China increases exports of fresh and frozen vegetables to Japan. Electronic Outlook Report from the Economic Research Service, USDA, August 2002.

http://www.ers.usda.gov/publications/vgs/aug02/vgs292-01/vgs29201.pdf

Huang Y and Khanna T (2003). Can India overtake China?. *Foreign Policy*, July-August 2003.

Hurd RG and Sheard GF (1981). Fuel saving in greenhouses: the biological aspects. *Grower Guide 20*. London: Grower Books, 55 pp.

ICEX (2002). Estudos de mercado. China: Mercado de la Tecnología Agrícola. Oficina Economica y Comercial de la Embajada de Espana en Pekin. 94 pp.

http://portal.icex.es/staticFiles/MBCHINATECNOLOGIAAGRICOLA_1429_.pdf

ISHS (2003). International Society for Horticultural Science. http://www.ishs.org/

IPPC (2003). Peat lands around the world, China. Irish Peatland Conservation. Council's.

http:/www.ipcc.ie/wpchina.html

Jensen MH (2001). Controlled Environment Agriculture in deserts, tropics and temperate regions- A world review. http://ag.arizona.edu/ceac/research/archive/ceawr_pe.htm

Jetro (2002). Japan Imports. http://www.jetro.go.jp/ec/e/market/mgb/3-35.pdf

Jiaming C (2003). A new approach in Xiaotangchan. UA Magazine. pp.40-42

http://www.ruaf.org/no9/40_42.pdf

Jiang L (2002). China's Peoples Republic. Market Development reports. Auction: a new way of fruit and vegetable trading in South China. USDA Foreign Agricultural Service Gain Report, October, 2002.

http://www.atoguangzhou.org/updoc/upfile/20037111013310.doc

Jiang W, Liu W, Yu H , Zheng G (2002). Development of eco-organic type soilless culture in mainland China. Abstract Proceedings of the ISHS XXVI International Congress, Canada, p. 313.

Jiang W, Qu D, Mu D and Wang L (2004). Protected Cultivation of Horticultural Crops in China. In: *Horticultural Reviews*, J. Janik (ed), Vol. 30, pp. 115-162.

Jiangsu Agriculture Government (2003). www.jsagri.gov.cn

Jinyu L, Guiying L, Renjun G and Qiyi S (1997). Seed coating Technology and seed industry in China. In: *Seed Industry and Agricultural Development. Chinese Association of agriculture Development*, M.Agriculture China, China Seed Group Corporation(Eds), pp.686- 695.

Jouët, J (2001). Plastics in the world. *Plasticulture*, 120:108-126.

Keijzer P (2003). Market trends, analysis and scenarios for the ornamental markets of emerging China. MSc Thesis, Wageningen University, The Netherlands, 42 pp.

Knaflewski M (2003). Horticulture in Poland. *Chronica Horticulturae*, 43 (2): 26-31.

Koo B, Pardey, PG, Qian K and Zhang Y. (2003). The economics of generating and maintaining plant variety rights in China. EPTD discussion paper n. 100, 40 pp.

http://www.ifpri.org/divs/eptd/dp/papers/eptdp100.pdf

Kotschi J, Schrimpf B, Minghui Z (2000). China: organic industry status.

http://www.organicts.com/organic_info/countries/china/status.html

Kunming Institute of Botany (2003). http://www.kib.ac.cn

Lal R. (2002). Soil carbon sequestration in China through agricultural intensifiaction and restoration of degraded and desertified ecosystems. *Land Degradation and & Development*, 13: 469-478.

La Malfa G (2003). Origine, fisionomia e sviluppo dell'orticoltura protetta. *Italus Hortus*, 10 (3), 14-26.

Larkcom J (1984). Chinese methods of pest and disease control. *Garden*, Vol. 109 (II), November , 442-447.

Li Y, Li B and Wang C (2003). Cooling of Venlo Greenhouse with shading and roof sprinkling in middle China. In: Abstracts of the 2003 Sino-Dutch Symposium on Modern Protected Horticultural Production, 28 October 2003, Beijing. p. 18.

Liang R (2000). The Chinese flower industry by numbers. *Floracultura International*, April 2000, 36-38.

Liu W, Li S, Chen D (2002). Effects of organic nutrient solution on growth and quality of hydroponic pak-choi. Abstract Proceedings of the ISHS XXVI International Congress, Canada, p. 104.

Lohmar B, Wang J, Rozelle S, Huang J, Dawe D (2003). China's Agricultural Water Policy Reforms: Increasing Investment Resolving Conflicts and Revising Incentives. USDA, Agriculture Information Bulletin, n. 782.

http://www.ers.usda.gov/publications/aib782/aib782.pdf

Lu H (2003). Institutional Arrangements in Fresh Vegetable Supply Chains: A case study in Nanjing area, P.R. of China. Wageningen University. 9 pp.

Ma S, Huang J, Wang D and Qu D (2000). China. In: *Dynamics of vegetable production, distribution, consumption in Asia.* M. Ali (Ed). Asian Vegetable Research Center. pp.69-97.

Mangen H (1998). Prospects of micro irrigation and fertigation in Chinese agriculture. IBC Conference, Beijing, 12pp. http://www.dsw.co.il/pdf/1-6.pdf

Mello E (2003). China is playing a growing role in global vegetble trade. FAS/USDA. February 2003. http://www.fas.usda.gov/info/agexporter/2003/February/pgs13-15.pdf

Moustakerski P (2001). China, Peoples Republic of Retail Food Sector Report, USDA Foreign Agricultural Service Gain Report, February 2001. http://www.fas.usda.gov/gainfiles/200111/130682605.pdf.

NATESC (2001). PAC meeting: Country report China, China National Agro-Tech Extension and Service Center, China National Agro-Tech Extension and Service Center, 8pp.

http://www.communityipm.org/docs/PAC_2001/China_PAC2001.pdf

NBSO (2002). The flower sector in the Yunnan Province Netherlands Business Support Office Kuming, 7 pp. http://www.nlembassypek.org/01_20020730_flower.pdf

NBSO (2003). The Yunnan Province. Netherlands Business Support Office Kuming.

(unpublished)

OECD (2002). China in the global economy: agricultural policies in China after WTO acession, ISBN 92-64-19886-5, 322 pp. http://oecdpublications.gfi-nb.com/cgi-in/OECDBookShop.storefront/EN/product/142002141P1

Öztürk A, Deviren, A. and Özçelik, A, (2001). Methyl bromide in Turkey. http://www.un.org.tr/unido/documents/METHYL%20BROMIDE%20IN%20TURKEY1.doc

PANNA (2003). Pesticide Residues a Major Threat to China's Ag Exports. Pesticide American Network North America.

http://www.panna.org/resources/gpc/gpc_200304.13.1.19.dv.html

Park MH and Lee YB (2001) . Effects of CO_2 Concentration, Light intensity and nutrient level on growth of leaf letttuce in a plant factory. *Acta Horticulturae* 548:377-384.

Peopledaily.com (2002). Yunnan Broken Through in the Taming Techniques of Wild Flowers. http://fpeng.peopledaily.com.cn/200009/19/eng20000919_50858.html

Pérez J.J, López J and Fernandéz MD (2002) La agricultura del surest: situatión actual y tendencias de las estructuras de producción en la horticultura. In: Álvarez-Coque J.M. (ed), *La Agricultura Mediterránea en el sieglo XXI.* Mediterraneo Economico,. Instituto Cajamar. pp. 140- 158.

Plum L (2001). China, a country of contrasts. *FloraCulture International.* November, pp.6-8.

Post W and Weimin L (2002). Dutch horticultural development and its importance to China. A comparative analysis. LEI-DLO Repot, Wageningen University, The Netherlands Rapport 2.02.11; ISBN 90-5242-749-6

http://www.lei.dlo.nl/publicaties/PDF/2002/2_xxx/2_02_11.pdf

PPI (2003). Organic Agriculture's Impact on the Food Quality and the Environment: A China Perspective. Potash & Phosphate Institute. http://www.ppi-far.org/ppiweb/sechina.nsf/$webindex/A1D6ADA378E165F548256C620031BF9E

Post JH and Zhang XY (2003). Nursery and nursery products in Beijing, Tianjin, Shandong and Shanghai. LEI-DLO Report, Wageningen University, The Netherlands.

http://www.lei.dlo.nl/publicaties/PDF/2003/2_xxx/2_03_10.pdf

Potash and phosphate Institute (2003). http://www.ppi-ppic.org/ppiweb/far.nsf

Pray C (1999). Public and private collaboration on plant biotechology in China. *AgBioForum*, 2 (1): 48-53.

Pray CE (2001). Public-Private sector linkages in research and development : biotechnology and the seed industry in Brazil, China and India. *American Journal Of Agricultural Economics* 83: 742-747.

Qing X and Branson A (2002). China, People's Republic . Planting seeds New Plant Variety Protection. USDA Foreign Agricultural Service, Gain Report October 2002. http://www.fas.usda.gov/gainfiles/200204/135684011.pdf

Qu S (2002). Oriental vegetables-History and status of vegetable industry. Abstract Proceedings of the ISHS XXVI International Congress, Canada, p. 313.

Reinders U (2002). China, waar een groot land klein kan zijn. *Vakblad Voor de Bloemisterij*, 35, 20-22.

Royal Netherlands Embassy (2003). Beijing Report 2003.

http://www.nlembassypek.org/br.pdf

Shian C (1997). China's Seed Industry. In: *Seed Industry and Agricultural Development.* Chinese Association of agriculture Development, M.Agriculture China, China Seed Group Corporation (Eds), pp.8-13.

Shields D (2001). China Fruit and Vegetable sector: a changing market environment. Economic Research Service / USDA, Jun-July 2001.

http://www.ers.usda.gov/publications/AgOutlook/june2001/AO282e.pdf

Shields A and Tuan FC (2001). China's fruit and vegetable sector in the changing marketing environment. *Chronica Horticulturae*, 41, 3 , 20-22.

Shijun LE, Lihong G, Suping Z, Gaoqiong L, Wei L (1998). *Acta Horticulturae,* 467: 253-257.

Shoof R (1998). China pushing for agricultural purity, Associated Press.

http://www.hartford-hwp.com/archives/55/346.html

Snodgrass D (2002). China Commercial Brief, Foreign Commercial Service, American mbassy, Beijing, Vol. 2 No. 105, February 26

http://www.usembassy-china.org.cn/english/commercial/english/highlights/2.html

Songlin Z (1997). Vegetable production and its future development in China. *Chronica Horticulturae*, vol. 37, n.4, 16.

Sonneveld C (2002). Protected cultivation in Shandong. Report of a visit (17 Sep- 10 Oct. 2002), 9 pp.

Southeast University (2003). Basic Information on Jiangsu Province.

http://www.seu.edu.cn/EC/english/js10.htm#js12

SPI (2002). InnoChina: A study on the policies, structures and training programmes Which have evolved to encourage innovation in the Science and Technology Sector of the People's Republic pf China. Sociedade Portuguesa de Inovação, 86 p..

http://www.spi.pt/documents/studies/InnoChina-study.pdf

Sun ZF (2003). General situation of protected agriculture & development of the key technology in China. In Abstracts of the 2003 Sino-Dutch Symposium on Modern Protected Horticultural Production, 28 October 2003, Beijing. p. 21.

Techliner (2000). Agricultural films: types and applications

Stanghellini C, Kempkes FLK, Knies P (2003). Enhancing Environmental Quality in Agricultural Systems. *Acta Horticulturae*, 609: 277-283.

The Economist (2002). Chinese Biotechnology. Biotech's yin and yang. December 14th, 2002.

The Economist (2003). Is the wakening giant a monster? February 15-21th, 65-67.

UNIDO (1999). Sections I MB and alternatives for soil fumigation in China. Section II: Trials description. United Nations Industrial Development Organisation. pp. 23-96. http://www.uneptie.org/ozonaction/unido-harvest/pdf/china-section1.PDF

USDA (2002). China: En route to a new role in global agriculture. Agricultural Outlook, May 2002

Van Beukering P (1999). Plastics recycling in China: an international lifecycle approach.IVM report W99 05, May 1999. http://lnweb18.worldbank.org/ESSD/envext.nsf/44ByDocName/PlasticsRecyclinginChinaanInternationalLifeCycleApproach1999525KPDF/$FILE/PlasticsRecyclinginChinaanInternationalLifeCycleApproach1999.pdf

Van der Lee H (2003). We hebben hier akelig veel in straling. *Oogst Tuinbouw*, April 2003, pp. 34-35.

Von Zabeltitz C (1999). Greenhouse Structures. In: *Ecosystem of the World 20. Greenhouse Ecosystems*. G. Stanhill and H.Z. Enoch (Eds.). Elsevier Amsterdam.

Wade J (2002). China People's Republic Planting seeds Annual 2002. USDA Foreign Agricultural Service , Gain Report, 38pp

Wang SY (2001). The possibilities of farmers co-operations(tives) in floriculture development in Yunnan Province. Student Report Larenstein, Deventer, the Netherlands, 43 pp.

Wang J and Anning Z (2002). The prospects and current status of protected fruit cultivation in Shandong province. Shandong Institute Pomology, Taian. 5pp.

Wang Y, Zhang Y, Zheng W. (2003). Water resources and potential of seawater desalination in Shandong peninsula. Desalination 157:269-276.

Wei Y, Fan Y, Wang M, Wang J (2000). Composting and compost application in China. *Resources, Conservation and Recycling* 30: 277-300.

Wei M, Xing Y, Wang X, Ma H (2002). CO_2 environment in lean-to solar greenhouse and effects of CO_2 enrichment on photosynthetic rate and dry matter production in cucumber. Abstracts of the XXVIth International Horticultural Congress, Canada, p.411.

Jiang W, Wei L, Hongjun Y, Guanghua Z. (2000). Development of Eco-organic type soiless culture in Mainland China. http://www.wtzpchina.com/eco.html Accessed 28 October 2002

Jiang W, Wei L, Hongjun Y, Guanghua Z . (2002). Development of Eco-organic type soiless culture in Mainland China. Abstract Proceedings of the ISHS XXVI International Congress, Canada, p. 418.

Weili W. (2003). Strategies and technologies to alleviate ground water pollution from nitrogen fertilization in intensive cropping areas in China. Pilot Course: Promoting Environment-friendly Agriculture in China (I). World Bank Institute.

http://www.worldbank.org/wbi/sdruralpoverty/china_efa/english/resources.html

Weimin L (2001). Recent Agriculture in the Yangtze Delta: General Review. Agricultural Economics Research Institute (LEI), The Hague, the Netherlands, 113 pp.

Wernett HC (2000). China builds on decade of progress. *FlowerTech*, Vol.3, n.5, 22-25.

Wittwer S (1987). The plastic revolution. In: *Feeding a billion. Frontiers of Chinese Agriculture.* Wittwer S, Yu Y, Sun Han, Wang Lianzheng (Eds). Michigan State University Press. pp 381-390.

Wolf J, Van Wijk, Cheng X, Hu Y, Van Diepen CA, Jongbloed AW, Keulen H, Lu CH, Roetter R (2003). Urban and periurban agricultural production in Beijing municipality and its impact on water quality. *Environment & Urbanization*, 15 (2): 141- 156 .

http://www.lei.dlo.nl/northsouth/files/eb6b182215119634f2dfde8965d5bb70.pdf

Yanqing W (2000). Integrated pest management (IPM) and green farming in rural poverty alleviation in China. Proceedings of the Regional Workshop on Integrated Pest Management and Green Farming in Rural Poverty Alleviation, Suwon, Republic of Korea, 11-14 October 2000, pp 32-40.

http://www.unescap.org/rural/doc/ipm2002/ch04.pdf

Xie Z, Auberson-Huang L., Malnoë P, Yao H, Kaeppeli O (2002). Comparison of driving forces in sustainable food production and the future of plant biotechnology in Switzerland and China. *Trends in Plant Science*, 7 (9): 416-418.

Yi-Zhong C and Zhangen Z (2000). Shanghai: trends towards specialised and capital-intensive urban agriculture: In: *Growing Cities Growing Food: Urban Agriculture on the Policy Agenda.* Bakker, M., Dubbeling, M., Sabel-Koschella, U., Zeeuw, H. (Eds). DSE, Feldafing, Germany. ISBN 3-934068-25-10. pp.467-475.

http://www.ruaf.org/reader/growing_cities/Shanghai.PDF

Yongchen D, Shanshu D, XinWei, C, Xiaoxuan W, Shude L, Zhenhua G and Dewei Z (1997). Different responses to low light intensity of two tomato genotypes differing in adaptability to protected cultivation. In: *Seed Industry and Agricultural Development.* Chinese Association of agriculture Development, M.Agriculture China, China Seed Group Corporation(Eds), pp.643-649.

Yonggong L (1998). Institutional and policy reform of rural extension in China during the transition towards a market economy.

http:/www.fao.org./docrep/W9699E/w9699e09.htm

Yong-gong L and Guo-jun Q (2002). Socio-economic study on farmers adoption of integrated pest management (IPM) strategies in Brassica vegetable crops in China. Working paper Series, Number 40, ACIAR. 34 pp.

http://www.aciar.gov.au/web.nsf/doc/JFRN-5J4729/$file/IAP_WP40.pdf .

Young B (2001) Seed Production. Crop and Soil News/Notes OSU Extension Service, Vol. 25, n.2. http://www.css.orst.edu/newsnotes/0104/seed-prod.html

Yuan B, Kang Y, Nishiyama S (2001). Drip irrigation scheduling for tomatoes in unheated greenhouses. *Irrigation Science* 20: 149-154.

Yunguan X (2000). Organic farming in China: the strategy for training and extension. *Ecology and Farming*. 23: 12-13.

Yunnan Agricultural University (2003). YAU 2003. http://www.ynau.edu.cn, 2003

Yunnan Flower Association (2003). http://yunnan-flower.org.cn, 2003

Zang Z Z (1999). Update development of protected cultivation in Mainland China. *Chronica Horticulturae*, Vol. 39, n.2, 11-15.

Zang Z (2002). The development and prospect on protected cultivation in mainland China. The ISHS XXVI International Congress, Canada, p. 411.

Zeng D (2003). Evolution of the agriculture and agricultural practices in China. IFA Regional Conference for Asia and Pacific, October 2003.

http://www.fertilizer.org/ifa/publicat/PDF/2003_regional_cheju_zeng_slides.pdf
2004.

Zhang W (2002). Nitrate pollution of ground water and vegetables in intensive cropping area of North China. http://www.caas.ac.cn/Forum/Sort_by_Title/sort_by_title_38.html

Zhao L and Zhang D (2002). Ornamental plant resources from China. Abstract Proceedings of the ISHS XXVI International Congress, Canada, p. 313.

Zhao YX and Knag L (2000). Cold tolerance of the leafminer *Liriomyza sativae* (Dipt. Agromyzidae). *J App Ent.* 124:185-189.

Zheng S, Li W, Gao L, Wu P (2001). Assessment of postharvest handling systems for vegetables in Beijing. In: *Postharvest Handling of Fresh vegetables*. T. O' Hare, J. Bagshaw, W.Li, G. Johnson (Eds), ACIAR Proceedings 105 pp.

Zhou X, Dong R, Li S , Peng G, Zhang L, Hou J, Xiao J, Zhu B (2003). Agricultural Engeneering in China. http://cigr-eejournal.tamu.edu/Submissions/

Invited%20Overview%20Renjie%20Dong%2017Dec2003.pdf

Ziwen Y (2001). The fate of *Bacillus thuringiensis* Insecticides in China.

http://www.biotec.or.th/unesco /file%204.doc

Zweig D (2002). Internacionalising China: domestic interests and global linkages. Cornell University Press, Ithaca and London, 291 pp.

Appendix

Appendix I: Province/municipality rankings for ornamental production in 2000

Table 1. For cut flower production

Rank	Province or city	Production (million of stems)	Area (ha)
1st	Yunnan	1346	2065
2nd	Guangdong	466	2719
3rd	Sichuan	438	880
4th	Jiangsu	270	545
5th	Fujian	195	623
6th	Shanghai	141	351
7th	Hebei	132	457
8th	Zhejiang	121	307
9th	Liaoning	120	330
10th	Hubei	120	200

Source: Dutch Horticultural Board-LNV (2002).

Table 2. For flowering pot plants (e.g. rhododendron, poinsettia, cyclamen, phalaenopsis, bromelias

Rank	Province or city	Production (million units)
1st	Guangdong	245.0
2nd	Jiangsu	66.3
3rd	Fujian	60.0
4th	Hebei	37.0
5th	Beijing	14.9
6th	Shanghai	12.9
7th	Shandong	10.0
8th	Zhejiang	10.0

Source: Dutch Horticultural Board-LNV (2002).

Table 3. For foliage pot plant (e.g. cycas, tropical palms, ficus varieties, pachira)

Rank	Province or city	Production(millions)
1st	Guangdong	113.5
2nd	Sichuan	82.0
3rd	Hebei	37.0
4th	Jiangsu	15.6
5th	Henan	11.0
6th	Hubei	10.0
7th	Fujian	8.59
8th	Jiangxi	5.80
9th	Zhejiang	3.25
10th	Shandong	1.76

Source: Dutch Horticultural Board-LNV (2002).

Table. 4. For major bedding plants (begonia, salvia, dahlia, chrysanthemum and dendrathema varieties)

Rank	Province or city	Production (millions)
1st	Hainan	113.5
2nd	Guangdong	82.0
3rd	Hunan	37.0
4th	Jiangsu/ Shanghai/ Zhejiang	15.6
5th	Beijing	11.0
6th	Shandong	10.0
7th	Dalian	8.59

Source: Dutch Horticultural Board-LNV (2002).

Appendix II: List of the Chinese Partners

Chinese Academy of Agricultural Sciences (CAAS)

Prof. Qu Donggyu
Director General, IVF, CAAS
Chinese Academy of Agricultural Sciences (CAAS)
12 Zhongguancun South Street,
Beijing 100081,
People's Republic of China.
Tel. +86-1068919511 or +86-1068919531.
Fax. (0086-10)62174123

Prof. Sun Zhong-fu
Inst. of Agri. Environment and Sustainable Development/Sino-Japan Agri. Research Center
Chinese Academy of Agricultural Sciences (CAAS)
12 Zhongguancun South Street
Beijing, 100081
P.R. China
Tel. 86-10-62119558/62119685(Office)
Fax. 86-10-62119558
E-mail: sunzf@263.net

Netherlands Business Support Office - Kunming

Mr. Robbert Lambriks and Mrs. Yang Yang
Netherlands Business Support Office - Kunming,
Room 1604, Hongta Mansion
155 Beijing Road
Kunming 650011
P.R. China
Tel. +86 871 3578322,
Fax. +86 871 3578323
E-mail: nbsokm@public.km.yn.cn

Yunnan Agricultural University

Prof. Yu Yang
Director International Exchange and Cooperation Department,
Yunnan Agricultural University
Kunming ,
Yunnan 650201
P.R. China
Tel. +86 (871) 5228041
E-mail: yuyang136@yeah.net

Shandong Pomology Institute

Dr. Wang Jinzheng (Deputy Director)
Shandong Pomology Institute
Longtan Road 64
Taian
Shandong 271000
P R China
Tel. +86 0538 8266556 (office)
E-mail: wjz992001@yahoo.com.cn

Sino Dutch Horticultural Training and Demonstration Center
Mr. Wim Weerdenburg (Project Manager)
Sino Dutch Horticultural Training and Demonstration Center (SIDOHC)
Donghai State Farm, 2 Zhen Dong Road
Nanhui County
Shanghai 201303
P.R.China
Tel: +86.21.58291918 / 1885
Fax: +86.21.58291777 / 1878
E-mail: sidhoc@uninet.com.cn
Homepage: http://www.sidhoc.com.cn

Shanghai Jiao Tong University
Prof. Dr. Danfeng Huang
Shanghai Jiaotong University
School of Agriculture & Biology, Dep. Plant Science
No.2678 Qixin Road
Shanghai 201101
P.R.China
Tel. +86- 2164787808
E-mail: HDF@sjtu.edu.cn

Dr. Niu Qingliang
Shanghai Jiaotong University
School of Agriculture & Biology, Dep. Plant Science
No.2678 Qixin Road
Shanghai 201101
P.R.China
Tel. +86-2164786870 (Office)
E-mail:qlniu@hotmail.com

Yangzhou University
Dr. Xuehao Chen
Yangzhou University, College of Agriculture
Department of Horticulture
88 Daxue Road (South),
Yangzhou 225009,
Jiangsu, China
Tel. +86-5147979395 (office)
E-mail: Chenxhliu@hotmail.com,

Nanjing Agricultural University
Dr. Luo Weihong,
College of Agriculture
Nanjing Agricultural University
Nanjing 210095
P R China
Tel: +86-25-4395195
Fax: +86-25-4432420
E-mail: lwh@njau.edu.cn

Appendix III: List of Partners (Private companies)

De Ruiter Seeds

Strength through specialisation: De Ruiter Seeds, since 1945, specialises in breeding, producing and selling hybrid seeds and rootstocks, focusing specifically on annuals such as tomato, paprika and pepper, cucumber, aubergine and melon. The company supplies a wide range of high quality seeds within these product groups to growers across the world. Specialisation is the heart of the work at De Ruiter Seeds. The company has built up thorough knowledge and experience by concentrating on a limited number of plants. It has combined this with major investments in research and development, which have enabled it to offer a constant supply of new and improved varieties.

The company closely follows market signals in anticipating which seeds to develop and produce as client needs and wishes can differ strongly by region, country and market status. It produces varieties which have the required resistance and properties to allow for different modes of cultivation and climate conditions; or varieties with specific characteristics such as colour, size and taste. One example is the red, firm beef tomatoes for the American market and the pink, sweet tomatoes which are preferred in Japan. De Ruiter Seeds aims always to supply the best possible products which meet the demands of growers, trade and consumer

De Ruiter Seeds
P.O. Box 1050
2660 BB Berschenhoek
Tel: +31 (0)10 – 5292222
Website: www.deruiterseeds.com

DE RUITER SEEDS
HYBRID SEEDS

PTC+ (Pratical training Center)

PTC+ is an international training centre with five multi-functional training sites in the Netherlands. PTC+ focuses on all links in the production chain of plant and animal commodities, agricultural and food technology and natural areas. PTC+ offers a range of tailor-made courses and professional training programmes for national and international participants, based on the concept "Learning-by-doing". In the horticultural department for example: management courses for horticulturists and programmes on crop protection (incl. Integrated Pest Management). In addition PTC+ carries out international consultancies for governments, private companies and educational centres. Furthermore PTC+ assists in the implementation of projects for the transfer of agricultural knowledge, skills and technology, both in the Netherlands and in other countries.

PTC+
Zandlaan 25-29,
P.O. Box 32,
6710 BA Ede,
The Netherlands
Tel.: +31 (0)318 697111
Website: www.ptcplus.nl

ptc+
Practical Training Centre

Saint-Gobain Cultilène B.V.

SAINT-GOBAIN CULTILÈNE B.V. is one of the leading stonewool substrate suppliers for professional horticulture worldwide. SAINT-GOBAIN CULTILÈNE B.V. is a daughter-company of the SAINT-GOBAIN group of companies which is active in about 46 countries all over the world and which employs about 173,000 employees worldwide. SAINT-GOBAIN CULTILÈNE B.V. has started in the early 1980s and has fully specialized in stonewool substrate for professional horticulture. The product line of SAINT-GOBAIN CULTILÈNE B.V. consists of a full range of: Propagation products including stonewool growing blocks and germination plugs in different sizes. A complete line of stonewool growing slabs in many dimensions, sleeved and unsleeved, for single-year, bi-annual and multi-annual use in both horticulture and floriculture. SAINT-GOBAIN CULTILÈNE B.V. is both ISO – and KIWA – certified. Finally, SAINT-GOBAIN CULTILÈNE B.V. is a lean-and-mean company with short communication lines and a hight degree of innovation and therefore able to respond quickly to the ever changing needs of the horticultural industry worldwide.

SAINT-GOBAIN CULTILÈNE B.V.
Hoekeindsehof 1
2665 JZ Bleiswijk
The Netherlands
Phone: +31 (0)10 – 5294294
Website: www.cultilene.nl

Klasmann-Deilmann

Is a leading company in the international peat and substrate industry, with key expertise in the fields of harvesting and processing peat raw materials, production and application of peat, peat reduced and peat free substrates for commercial and professional growers, as well as potting compost for hobby gardeners. Klasmann-Deilmann is one of the product leaders at the highest level possible for quality and innovation. Klasmann's customer benefits and satisfaction are at the forefront of our thinking. Klasmann-Deilmann attach great importance to meeting customer requirements. We are not satisfied until we have found the best solution for both our customers and our suppliers, as trading partners. Klasmann-Deilmann wants to face and exceed its responsibilities for the protection of the environment and conservation of nature. Moreover, to make a further important contribution towards environmental protection with our composting plants by returning organic residual materials to the natural cycle.

Klasmann Deilmann GmbH
Georg Klasmann Strasse 2-10
49716 Geeste 4
Germany
Tel. +49 (0)59 37-31-0
Website: www.klasmann.de

Rijk Zwaan BV

Rijk Zwaan is a leading Dutch plant breeding company, which specialises in developing high quality varieties of vegetable crops and in production and sale of seeds of these varieties. The seeds are sold to professional growers in almost all countries of the world. The Rijk Zwaan Group, including several plant nurseries, employs more than 900 people of whom 300 work abroad in several subsidiaries in e.g. France, Spain, Turkey and Australia. For research and development the company has modern laboratories and highly qualified personnel to translate scientific knowledge into practical use in plant breeding. The most important crops are lettuce, tomato, cucumber, sweet pepper, cauliflower, spinach and carrots.

Rijk Zwaan BV
Burgemeester Crezeelaan 40
P.O. Box 40
NL-2678 ZG De Lier
The Netherlands
Tel.: + 31 174 53 23 00
Website: www.rijkzwaan.nl

Department of Plant Sciences, Wageningen University

Plant Sciences is one of five departments that constitute Wageningen University and it is a combination of 16 mainly botanically oriented chairs, 2 research schools and several general and technical facilities. The field of expertise is the plant and its functioning in its environment. The academic research and education takes place on the different aggregation levels from the molecule up to and including the agro-ecosystem and a lot of attention is paid to permanence and biological production. Development of knowledge and transfer of knowledge provide a better insight into the possibilities of plants. This knowledge is essential because of the growing world population and the increasing prosperity resulting in demand for more efficient and permanent production of plants, products of botanical origin, safe food and green raw materials. As a result of the combination of different approaches on academic level - molecular biology, biotechnology, bio-informatics, physiology, crop protection, ecology and systems analysis - and the close co-operation with practically-oriented research institutes within Wageningen University and Research Centre it is the cradle of totally new insights and perspectives.

Wageningen Universiteit
Departement of Plant Sciences
Postbus 16
6700 AA Wageningen
Tel. +31 317 483915
Website: www.dpw.wau.nl

Appendix IV: Visiting and advisory team

The Visiting team

Niek Botden (MSc.) (project leader) is an Agricultural Engineer from the Wageningen University with extensive knowledge and experience on both the Dutch and international horticultural sector from production and following supply chains in for example countries like US, Kenya, Columbia and Brasil. His working fields are greenhouse vegetables and cut flowers. He is specialised in greenhouse production systems and product quality chain management issues. At present he starts a new research and consulting company, named HortiVision B.V., which is positioned in between the horticultural sector and the research. It will act as switchboard by integrating horticultural technological, plant physiological and managerial aspects by bringing research and producers or chain participants together. Together with Dr. ir. Miguel Costa he was responsible for this project as project leader.

Dr. ir. Susana M.P. Carvalho graduated in Agriculture Engineering from University of Trás-os-Montes and Alto Douro (Vila Real, Portugal). In May 2003, she obtained her Ph.D. in Production Ecology & Resource Conservation from Wageningen University with the dissertation entitled *"Effects of growth conditions on external quality of cut chrysanthemum: analysis and simulation"*. She is specialised in crop physiology and modelling quality of ornamental crops. At present she works as research associate at the Horticultural Production Chains group, Wageningen University.

Dr. ir. Miguel Costa (project leader and organiser) graduated in Agriculture Engineering from University of Trás-os-Montes and Alto Douro (Vila Real, Portugal) and has a MSc in Sustainable Greenhouse Horticulture from the Instituto Superior de Agronomia (Lisbon, Portugal). In September 2002 he received his Ph.D. in Production Ecology & Resource Conservation from Wageningen University (The Netherlands) with the dissertation entitled *"The role of leaves in growth dynamics and rooting of rose cuttings"*. He is specialised in plant propagation and greenhouse production systems. Since October 2002 he works as research associate from the Horticultural Production Chains Group of the Wageningen University as manager of this project *"China Greenhouse Horticulture: situation and prospects"*

Dr. ir. Ep Heuvelink is assistant professor at the Horticultural Production Chains group of Wageningen University. He studied Horticulture at Wageningen University and his dissertation, entitled *'Tomato growth and yield: quantitative analysis and synthesis* was published in 1996. His field of expertise is ecophysiology and simulation models for crop growth, development and yield. His present research focuses on the interactions between greenhouse climate conditions and growth, yield and external quality of chrysanthemum, sweet pepper and tomato. He teaches in several courses on Crop Ecology, Greenhouse Technology and Methodology in Crop Experimentation and several MSc and PhD students conduct their thesis work under his supervision. He published a large number of papers in international refereed journals and is a member of the editorial board of *Scientia Horticulturae* and *Journal of Horticultural Science and Biotechnology*. He acted as chairman of the advisory group of the China project and visited China several times, giving guest lectures on crop physiology, crop modelling and greenhouse climate control. He is guest researcher/professor of the Shandong Pomology Institute.

Dr. ir. Oliver Körner graduated as agricultural engineer in horticultural sciences from University of Hannover (Germany). In June 2003, he received his Ph.D. in Production Ecology & Resource Conservation from Wageningen University (The Netherlands) with the dissertation entitled *"Crop Based Climate Regimes for Energy Saving in Greenhouse Cultivation"*. His main interests are in greenhouse environmental control and crop growth modeling. Since April 2003, he holds a position as Assistant Professor at the Department of Agricultural Sciences (Section of Horticulture) at the Royal Veterinary and Agricultural University in Copenhagen, Denmark.

Anke van der Ploeg (MSc.) studied biology at Wageningen University and completed her MSc in 2001. Since 2002 she is working on a four year Ph.D. project in the Horticultural Production Chains group of Wageningen University. In this project, which is aimed at increasing energy efficiency, her work focuses on the differential physiological and morphological effects of a lower temperature in the greenhouse on growth and development of several tomato and chrysanthemum cultivars. She is specialised in crop physiology of both vegetables and ornamentals

The advisory team

Dr. Ximing Hu has a MSc. Degree in Plant Breeding and a Ph.D. from the Wageningen University, The Netherlands with the dissertation entitled "Growth and Productivity of Cut Rose as related to the rootstock". Dr. Hu has also a MBA from the Nyenrode University, The Netherlands Business School, The Netherlands. He is an expert on matters related with the Chinese Horticulture and he works as consultant on greenhouse cultivation of cut flowers.

Prof. Dr. ir. Hugo Challa (Deceased) In 1971 he received his MSc. Degree in Forestry, and in 1977 his Ph.D. degree, both at the Wageningen Agricultural University, Wageningen, The Netherlands. In 1971 he was appointed as research assistant (Ph.D.-student) at the Centre of Plant Physiological Research (CPO), in 1974 as Plant physiologist at CPO/CABO, Wageningen and in 1987 as Professor in Horticulture at Wageningen Agricultural University. After reorganisation of the plant science department in 1998, he became Professor in Horticultural Farm Technology, linking greenhouse horticulture with engineering. He has been Vice President of the International Society for Horticultural Science from 1990 till 1994 and member of the Editorial Board of Agricultural Systems from 1988 till 2000. He has supervised over 20 Ph.D. students (three of them are elements of the visiting group) and was involved as author, co-author and editor of books and many research papers. His interests were (greenhouse) crop and (greenhouse) environment, process based environmental control and modeling of growth and yield of greenhouse crops.

Dr. ir. Martien Beek has a Ph.D. degree from Wageningen University and a broad experience in horticultural production, and marketing in China from missions since 1993. At present he is owner of a private consulting company "Beek Advisory Services" which provides independent project advice, organises training programmes and study tours in the field of horticulture. The basic aim of the enterprise is to contribute to a sustainable growth in a changing agricultural sector with a focus on how technical, socio-economic, and organisational issues can be handled effectively at high levels of productivity. "Beek Advisory Services" plays an intermediate role in the Dutch horticultural knowledge and information network, with advice and training based on the local circumstances and opportunities, which are accessible to growers. Contact address: Bowlespark 19, 6701 DR Wageningen, The Netherlands, E-mail: mabeek@diva.nl

Prof. Dr. Olaf van Kooten is Chair of Horticultural Production Chains Group of the Wageningen University. MSc in Experimental Biophysics (1980) from the Free University of Amsterdam and a Ph.D. in Plant Photosynthesis from Wageningen University, The Netherlands. He is specialised in using non-destructive measurement techniques for determining internal physiological states in combination with dynamic models to interpret measurements and predict future quality related behaviour under specified environmental conditions. Prof. Van Kooten is involved in the development of new non-destructive techniques to measure and predict shelf life of fruits and vegetables and on research on consumer behaviour and marketing trends as well as on the development of new business concepts for the integral chain approach. He is also guest consultant/professor of the Shandong Pomology Institute and the Shandong Academy of Agricultural Sciences

Appendix V: Visiting program

Shanghai municipality

12/10 Sunday	13/10 Monday	14/10 Tuesday	15/10 Wednesday	16/10 Thursday	17/10 Friday	18/10 Saturday
7.30 am. Arrival to Pudong Airport	Fengxian Nursery of the Da Han Horticulture Dev. Co. (Shanghai)	Sino-Dutch Horticultural Demonstration Center (SIDOHC) (Nanhui County) Pudong)	Shanghai Yuanyi Seedling Co. (Pudong)	Shanghai Academy of Agricultural Science (SAAS) (Shanghai)	Shanghai Jiantong University[2] (Mini-ymposium)	Street markets of garden and pot plants in Shanghai
Meeting with Mr. Kelvin Tan (Klasmann Asia Manager)	Garden-center Da Han Horticulture Dev. Co. (Shanghai)[1]	Shanghai Flower Port (Pudong)	Shanghai Sunqiao Agricultural Science & Technology CO., Ltd. (Pudong)	Shanghai Agricultural Machinery Institute (Shanghai)	Shanghai Jiantong University (visit to greenhouse facilities	FREE

[1] Oral communication from HPC group
2 Mini-symposium

Yunnan province

18/10 Saturday	19/10 Sunday	20/10 Monday	21/10 Tuesday	22/10 Wednesday	23/10 Thursday	24/10 Friday
Hort Expo Kunming (Kunming)		Yunnan Agricultural University[1] (Kunming)	Kunming ChenNong Green Products Co. (Chengong county, Kunming)	World Expo '99 garden (Kunming)	Unida Co. (Kunming)	Yunnan Xinli Greenhouse Engineering Co. (Kunming)
		Local growers (Chengong county, Kunming)	Kunming Speedling Co. (Guandu district, Kunming)	Kunming Nongfengyuan Trade Co. (Guandu district, Kunming)	Yunnan Yunda Shunshine Floriculture Development Co. Ltd. (Songming county, Kunming)	Kunming Gelin Greenhouse Horticultural Co. (Kumming)
			Dounan Wholesale Flower Market (Chengong county, Kunming)	Kunming Jin Yuan Flower Industry Co. (Kunming)	Yunnan Yingmao Flower Industry Co. (Xiaoshao Township, Kuming)	NBSO (Kunming)
			Kunming International Flora Auction Trading Centre Co. (KIFA) (Chengong county, Kunming)			
			Yunnan United Floral Transport & Marketing Co. (FLY) (Chengong county, Kunming)			
			Kunming Ban Fan Floriculture (Guangdu district, Kunming)			

1 Oral communication by the two HPC members.

Jiangsu province

19/10 Sunday	20/10 Monday	21/10 Tuesday	22/10 Wednesday	23/10 Thursday	24/10 Friday	25/10 Saturday
Xisan State Modern Agricultural Experimental Center (Xisan)	Yangzhou City Development Company (Yangzhou)	Yangzhou University [1] (Yangzhou)	Solar greenhouse area (Huian city periphery)	Large Scale Demonstration Garden for Green Food, Baguazhou, Qixia (Nanjing)	Nanjing Agricultural University [2] (Nanjing)	Nanjing Liangmao Agricultural Development Co. Ltd., Hengxi Town, Jiangning District
Wuxi Modern Horticultural Seedling (Wuxi)	Pot plant company	Grower garden center Bonsais and pot plants (Jiangdu)	Huian Vegetable Research Institute (Huian)	Experimental Greenhouses from JAAS – Jiangsu Suyuan Hortechnology Ltd. (Nanjing)		
		Yangzhou Athena Gardening Technology Developing Co. Ltd (Jiangdu)		Euro-Asia Fruits and Vegetables Group (Nanjing)		
				Nanjing Flower West Market (Nanjing)		
				Nanjing Baiyunting Vegetable Wholesale Market (Nanjing)		

1 Oral communication by the two HPC members.
2 Oral communication by the two HPC members. Practical on modelling by Dr. E. Heuvelink followed by visit to the facilities.

Shandong province

27/10 Monday	28/10 Tuesday	29/10 Wednesday	30/10 Thursday	31/10 Friday	1/11 Saturday
Outdoor ornamental nurseries in (Shengzhuan)	Shandong Academy of Agricultural Sciences (SAAS) (Jinan)	Ornamental and pot plant Shandong Forestry department (40 km from Jinan)	Yonghong Flower Company of Qinzhou, (small grower) (Qinzhou, near Weifang)	RijkZwaan Shouguang demonstration center (Shouguang)	Street market of pot plants, fruits and vegetables (Taian)
Flower and pot plant indoor market (XiaoJing Flower Market) (Taian)	Vegetable Institute of SAAS (Jinan)	Jinan Botanical garden (Jinan)	Indoor pot plant markets (Qinzhou, (near Weifang)	D-Mart horticulture supplier (Sanjuanzhu Village)	
Shandong Pomology Institute[1] (Taian)	Indoor market of pot plants and flowers (Jinan)			Shouguang wholesale vegetable market (Shouguang)	
Shandong Agricultural University[1] (Taian)					

1 Oral communication by the two HPC members.

Beijing municipality

27/10 Monday	28/10 Tuesday	29/10 Wednesday	30/10 Thursday	31/10 Friday	1/11 Saturday
China Beifang Seed Market North Seed Trade Market (Haidian district Beijing)	Chinese Academy of Agricultural Science (CAAS) (Beijing)1	Institute of Vegetables and Flowers (CAAS) (Beijing)	Beijing Kain Organic Fertilizer Co. (Haidian district)	Hancunhe Tourism Development Co. Fangshan district)	Chaoda Modern Agriculture Group - Pinggu Base (Pinggu district)
Beijing Laitai Flower and Plant Trade Centre (Beijing)		Beijing Glorious Land Agric. Co. (Beijing)	Biology Engineering Co.	Beijing Shengfangyuan Huahui Zhongzhi Jidi	
Jingpeng Greenhouse Engineering Co (Haidian district, Beijing)			Forestry Research Institute (Beijing)	Dutch Embassy (Beijing)	
			Jetgreen Horticulture (Chaoyang District)		

1) 2003 Sino-Dutch Symposium in Modern Horticulture