Dutch agricultural development and its importance to China

Case study: The evolution of Dutch greenhouse horticulture

J.S. Buurma

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A brief description of the evolution of greenhouse horticulture in the Netherlands in the period 1950-2000, including a statistical review of areas, physical yield and labour productivity, and a qualitative review of technical and institutional development. The report first provides the story of a Dutch greenhouse vegetable grower. Furthermore, horticulture in the Yangtze Delta is positioned on the time axis from 1950-2000. Traditional horticulture and industrial horticulture in the Yangtze Delta show many technical similarities to Dutch greenhouse horticulture in 1960 and 1980, respectively. Finally, some recommendations for improving the institutional coherence in horticulture in the Yangtze Delta and for involving Dutch agribusiness are given.

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Preface

'The Experience of Dutch Agricultural Development and its Importance to China' is a joint research project of the Agricultural Economics Research Institute of the Chinese Agricultural Academy of Sciences (IAE-CAAS) in Beijing and the Agricultural Economics Research Institute (LEI) of Wageningen University and Research Centre in The Hague. The project is jointly financed by the Chinese Ministry of Agriculture, the Dutch Ministry of Foreign Affairs (Asian Facility) and the Dutch Ministry of Agriculture, Nature Management & Fisheries. The objectives of the project are:

- To reveal the causes of the large differences between agricultural productivity in China and that in the Netherlands, and to find ways to improve the efficiency of Chinese agriculture.
- To analyse the developments in Chinese agriculture with special reference to market opportunities for Dutch agribusiness.
- To provide the Chinese partners with on-the-job-training, so that they will become familiar with research approaches and methodologies used at LEI.

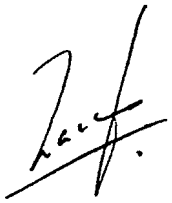
This case study details the technical and institutional development of Dutch greenhouse horticulture in the period 1950-2000, and provides an assessment of the current position of horticulture in the Yangtze Delta on the development path of Dutch horticulture. This assessment will provide Chinese policymakers and Dutch agribusiness with indications concerning the technical and institutional prerequisites for the further development of horticulture in the Yangtze Delta. It is hoped that it will provide a fruitful basis for Sino-Dutch cooperation in horticultural development.

The case study is a follow-up to the visit by Dutch researchers to Shanghai in May 2000, and the visits by Chinese researchers to the Netherlands in, for example, September 2000. These visits proved to be very useful in facilitating the exchange of thinking and observations between the Chinese and the Dutch researchers.

The case study was implemented by J.S. Buurma, senior researcher at the horticulture division of LEI. Thanks to the availability of a recent memorial volume entitled *One Hundred Years of Applied Research in Greenhouse Horticulture*, (J. van Doesburg, E. Kooistra, C. Vonk Noordegraaf and W. van Winden, 1999), it is possible to present an in-depth description of the technical and institutional developments. The development path is further depicted by a statistical review of economic data and the story of a successful Dutch greenhouse vegetable grower.

We hope the results will contribute to the further development of horticulture in the Yangtze Delta, and to fruitful cooperation between those involved in Chinese and in Dutch horticulture.

The managing director,



Prof. Dr. L.C. Zachariasse

Summary

This case study provides a brief description of the evolution of greenhouse horticulture in the Netherlands in the period 1950-2000. Its two main components are:

1) a statistical review of areas, physical yields and labour productivity;
2) a qualitative description of technical and institutional developments.

The reason for presenting the statistical review and the qualitative description is to provide starting points for further development of greenhouse horticulture in China, and especially in the Yangtze Delta. For this purpose, the current position of Yangtze horticulture on the time axis from 1950-2000 is assessed.

The statistical review is based on the large body of statistical data available at LEI. The main sources are the yearly agricultural censuses of the Central Bureau of Statistics and the Farm Accountancy Data Network of LEI. The qualitative description of the technical and institutional development has its roots in the memorial volume *One Hundred Years of Applied Research in Greenhouse Horticulture*.

The total greenhouse area in the Netherlands expanded from about 3,300 ha in 1950 to over 10,000 ha in 2000. However, the evolution was different for the various crop groups. The area under vegetables underwent tremendous growth, from 2,200 ha in 1950 to 5,100 ha in 1965. From then on, however, the expansion stopped and gradually dropped to a total area of 4,200 ha in 2000. In 1965, floriculture took off: it outstripped the vegetable sector in 1985, and reached an area of 5,900 ha in 2000. Between 1950 and 2000, the area devoted to fruit growing decreased from 780 ha to 30 ha, and that devoted to tree nurseries increased from 10 ha to 370 ha.

Within the greenhouse vegetable sector, a sequence of switches occurred, i.e. from hotbeds to greenhouses (1960-1970) and from unheated greenhouses to heated greenhouses (1970-1980). Within the greenhouse floriculture sector, also a sequential development occurred: expansion started with cut flowers (1970-1980), followed by pot plants (1980 onwards) and tree nurseries (1990 onwards).

Crop productivity and labour productivity increased tremendously over the course of time. In the period 1980-1996, physical yields of tomatoes, cucumbers and sweet peppers increased by 97%, 47% and 79%, respectively. At the same time, the physical yields of roses and chrysanthemums increased by 36% and 56%, respectively. In the period 1970-1976, labour productivity in cut flower production increased by about 30%. Owing to these improvements, costs of inputs per kg of product decreased tremendously. After correction for inflation, the main costs per kg of tomatoes decreased from NLG 4.44 in 1954 to NLG 1.36 in 1982. This price decrease gave Dutch tomatoes a very strong competitive position in Western Europe, and thus good export opportunities.

Starting from technical and institutional changes, the period 1950-2000 can be divided into four successive periods, each representing specific phases in the development path:

- 1945-1965: reconstruction after World War II;
- 1965-1980: mechanization; cutting labour costs;
- 1980-1993: application of computer technology;
- 1993-2000: change to demand-driven economy.

The above-mentioned economic and social developments had far-reaching technical and institutional effects on greenhouse horticulture in the Netherlands. In the period 1945-1965, much attention was focused on soil fertility, plant protection and improving varieties. The switch from hotbeds to greenhouses considerably improved labour productivity. Extension and research operated as troubleshooter and problem-solver, respectively, for individual growers. The auctions played an important role in knowledge exchange.

In the period 1965-1980, much attention was paid to greenhouse heating, climate control and planting material. The switch to natural gas and the mechanization of climate control and harvesting/grading strongly improved labour productivity. Liberalization of the EU market gave a strong impulse to export vegetables and flowers. The period was characterized by close cooperation between government and practice. The knowledge system played a leading role in this cooperation.

In the period 1980-1993, the personal computer enabled the application of many new technologies, such as the switch to substrate culture, trickle irrigation and CO_2 application. The knowledge system strongly supported the introduction of these new technologies by providing knowledge of climate control and by development of management systems. The auctions also gave support through data-processing facilities. Moreover, they developed guidelines for environmentally responsible cultivation.

In the period 1993-2000, the knowledge system and the marketing system underwent radical changes. Both extension and research were privatized and started working on a contract basis. The horticultural sector established a research coordination bureau to translate growers' problems into research questions and to negotiate specific contracts with research stations and institutes. The market for horticultural products changed from supply-driven to demand-driven. The position of the vegetable auctions was no longer sovereign. Growers' associations and trade marks were established to meet the needs of exporters and supermarkets. The auctions developed from a market place into a marketing partner for the buyers.

The position of horticulture in the Yangtze Delta on the time axis of Dutch greenhouse horticulture depends on the production system in question. Traditional horticulture and industrial horticulture in the Delta have many technical similarities with Dutch greenhouse horticulture in 1960 and 1980, respectively. Greenhouse horticulture in the Netherlands is characterized by a remarkable interconnection between knowledge, production and marketing. For Dutch horticulture, this seems to be an important success factor. Improving the interconnection between knowledge, production and marketing seems to be an important condition for speeding up the development of horticulture in the Yangtze Delta.

The institutional settings of Dutch horticulture in 1960 and 1980 imply the following recommendations for the knowledge system in the Yangtze Delta. To speed up the development of traditional horticulture, research and extension should concentrate on problem-solving and troubleshooting in close cooperation with growers. Information lines between research, extension and growers should be made as short as possible. These three stakeholder groups should cooperate as members of the same family.

To speed up the development of industrial horticulture, research and extension should try to combine the interests of industry and government. Research should in this case concentrate on knowledge development for the input industry, such as plant nurseries, potting soil producers, greenhouse constructors and mechanization firms. Demonstration projects like SIDHOC may serve as a source of inspiration for the development of appropriate technology for industrial horticulture in the Yangtze Delta.

Export to such countries as Japan and Singapore implies compliance with the international standards of 2000. This means introducing certification systems and third-party inspections. It also means translation of consumer preferences in the destination countries to product qualities and production systems in China. This will require a lot of market information and chain management. Therefore the Chinese knowledge system should intensify its cooperation with the country's export industry.

Dutch agribusiness should focus on exporting technical and institutional know-how rather than technologies. This implies close cooperation with public and private partners in China. Depending on the target group (i.e. traditional or industrial horticulture) cooperation should start from the 1960 or 1980 development level of Dutch horticulture. Institution building in both the knowledge system and the marketing system could be spearheads.

1. Introduction

This case study presents a brief description of the evolution of greenhouse horticulture in the Netherlands in the period 1950-2000. Its two main components are:

1) a statistical review of areas, physical yields and labour productivity;
2) a qualitative description of technical and institutional developments.

The reason for presenting the statistical review and the qualitative description is to provide starting points for further development of greenhouse horticulture in China, and especially in the Yangtze Delta.

The Chinese government wants to learn from the agricultural development process in the Netherlands in order to further develop agriculture and horticulture in China. Until now there has been no brief review of the technical and institutional backgrounds to the development of greenhouse horticulture in the Netherlands. This case study fills this knowledge gap.

The objective of this study is to provide starting points for the fruitful development of greenhouse horticulture in China. Such a fruitful development would provide promising prospects for the horticultural industry in both China and the Netherlands. In China the physical and economic output of horticulture may increase considerably and thus meet the needs of both producers and consumers. For the Dutch industry, a promising new market for horticultural knowledge and technology may develop.

The statistical review is based on the large body of statistical data available at LEI. The main sources are the yearly agricultural censuses of the Central Bureau of Statistics and the Farm Accountancy Data Network of LEI. The qualitative description of the technical and institutional development has its roots in the memorial volume *One Hundred Years of Applied Research in Greenhouse Horticulture*. Last but not least the story of a retired vegetable grower and his sons provided a source of inspiration for this case study. They indicated high yields and high labour productivity as the two main factors for success. These factors therefore receive a lot of attention in this study.

In preparation for the study, a Sino-Dutch research team went on a fact-finding mission to Shanghai, Wujiang and Chongming. The team found that consumer-oriented thinking and appropriate knowledge exchange are weaknesses in horticultural development in the Yangtze Delta (Buurma, van Horne and Xiaoyong; 2000). Consequently, knowledge and marketing are also given a lot of attention in this study.

The study starts by describing the development of a Dutch greenhouse vegetable enterprise between 1950 and 2000 (Section 2). Subsequently, the statistical review (Section 3) and the technical and institutional developments (Section 4) are reported on. After that, an assessment is made of the current position of greenhouse horticulture in the Yangtze Delta with regard to the development path of Dutch greenhouse horticulture (Section 5). Finally, recommendations for the future development of horticulture in the Yangtze Delta are made (Section 6).

2. Development of a Dutch greenhouse vegetable enterprise 1950-2000

In September 2000, a Sino-Dutch research team visited a retired greenhouse vegetable grower in the South Holland greenhouse district. The objective was to gain an impression of the development of a greenhouse enterprise between 1950 and 2000. We were also interested in the grower's opinion on what made his enterprise a success.

The following shows how the enterprise has developed since 1950.

1950 The grower returned from military service in Indonesia, eager to earn a living as a vegetable grower. He started with 2,000 m^2 of hotbeds (removable 75 x 150 cm frames). Cropping pattern: lettuce in spring, cucumbers in summer
1956 Construction of 1,000 m^2 of greenhouse. Financial support from the Ministry of Agriculture's credit guarantee fund.
1957 Cropping pattern in greenhouse: lettuce in spring, tomatoes in summer
High prices for tomatoes. Sufficient profit to repay the 1956 loan.
1958 Construction of 2,500 m^2 of greenhouse, including heating system.
Cropping pattern: lettuce in spring, tomatoes in summer, lettuce in autumn
1973 Greenhouse area expanded to 10,000 m^2, switch to heating with natural gas
Cropping pattern: tomatoes in spring and summer, lettuce in autumn
1980 First application of climate control computer in the greenhouse
1984 Greenhouse area expanded to 30,000 m^2, switch to artificial substrate
Cropping pattern: tomatoes year round (December-October)
1985 Yield level: 40 kg/m^2
1988 Switch to high-wire system in tomato production
First application of CO_2 fertilization in the greenhouse
1997 Grading of tomatoes contracted out to packing station
Focus on crop production and harvesting only
1999 Yield level: 60 kg/m^2
2000 Three locations with a total production area of 130,000 m^2
Management by the retired grower's two sons
200# Bringing together the production at one completely new location

The above is not representative in the sense that all vegetable growers were just as successful. Over the years, this vegetable grower bought greenhouses and/or land from neighbours who had stopped their enterprise. In 2000, about 35,000 m^2 of greenhouses were rented from a vegetable grower who wanted to lead a more steady life.

Nevertheless, we found it useful to ask the retired grower for the secret of his success. His answer was both simple and disarming: achieve high crop yields (kg/m^2) and high labour productivity (kg/h). Consequently, the task for researchers and advisers is to help growers to improve crop productivity and labour productivity.

3. Statistical review of Dutch greenhouse areas 1950-2000

In this section the trends in the Dutch greenhouse sector are described on the basis of the evolution of the greenhouse areas in the period 1950-2000. A distinction is made between areas for vegetables, fruits, cut flowers, pot plants and nursery trees. Moreover, the shift from hotbeds to greenhouses and that from unheated to heated areas are reviewed. These data are derived from the annual agricultural censuses carried out in the Netherlands.

Furthermore, some details on trends in physical yields, labour productivity and costs of production are presented. These details come from various LEI research reports.

Overall picture

Figure 3.1 shows the evolution of greenhouse areas in the period 1950-2000.

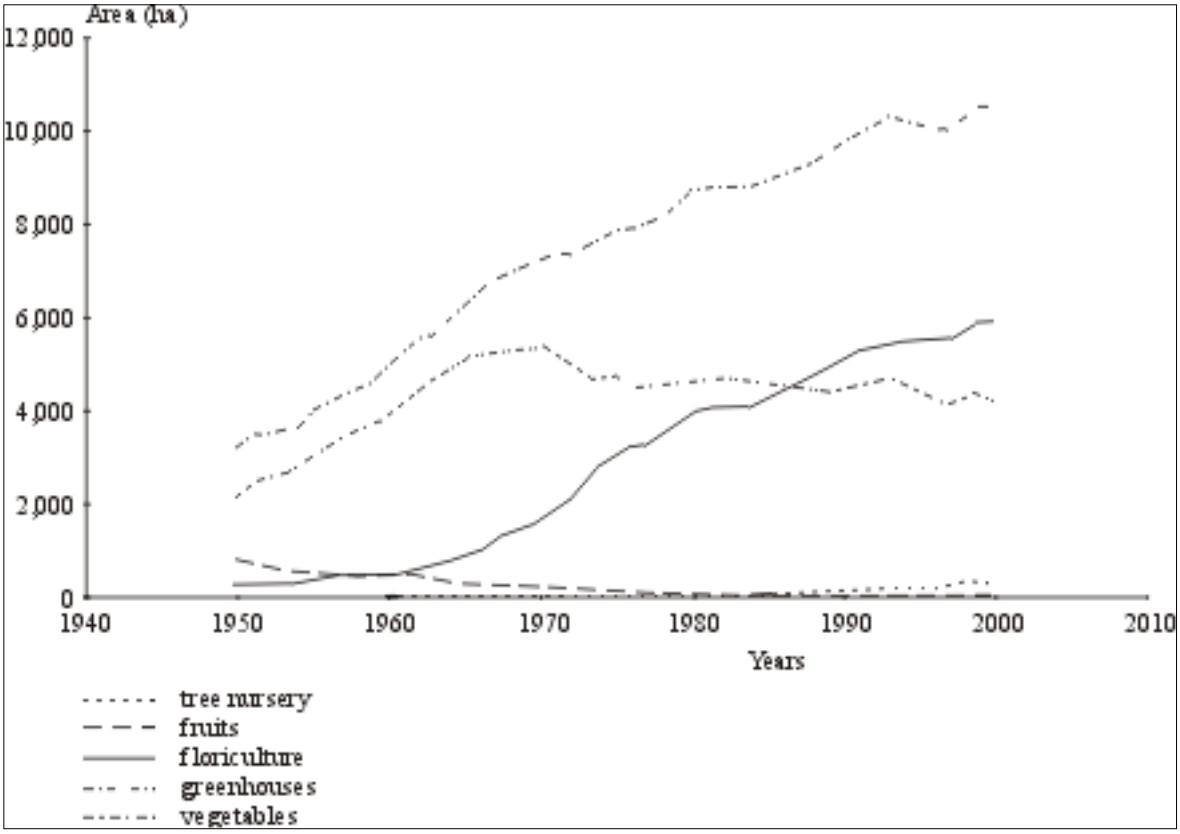


Figure 3.1 Evolution of the greenhouse areas in the Netherlands in the period 1950-2000

The total greenhouse area expanded from about 3,300 ha in 1950 to over 10,000 ha in 2000. However, the evolution was different for the various crop groups. The area under vegetables underwent tremendous growth, from 2,200 ha in 1950 to 5,100 ha in 1965. Then, however, expansion stopped and the area under vegetables gradually dropped, to reach 4,200 ha in 2000. In 1965, floriculture took off: it outstripped the vegetable sector in 1985 and reached an area of 5,900 ha in 2000. The figure further shows the trends for fruits and nursery trees. Fruit production in greenhouses nearly disappeared. On the other hand, the production area of nursery trees increased from 10 ha in 1965 to 370 ha in 2000.

Greenhouse vegetables

Figure 3.2 shows the evolutions within the greenhouse vegetable sector.

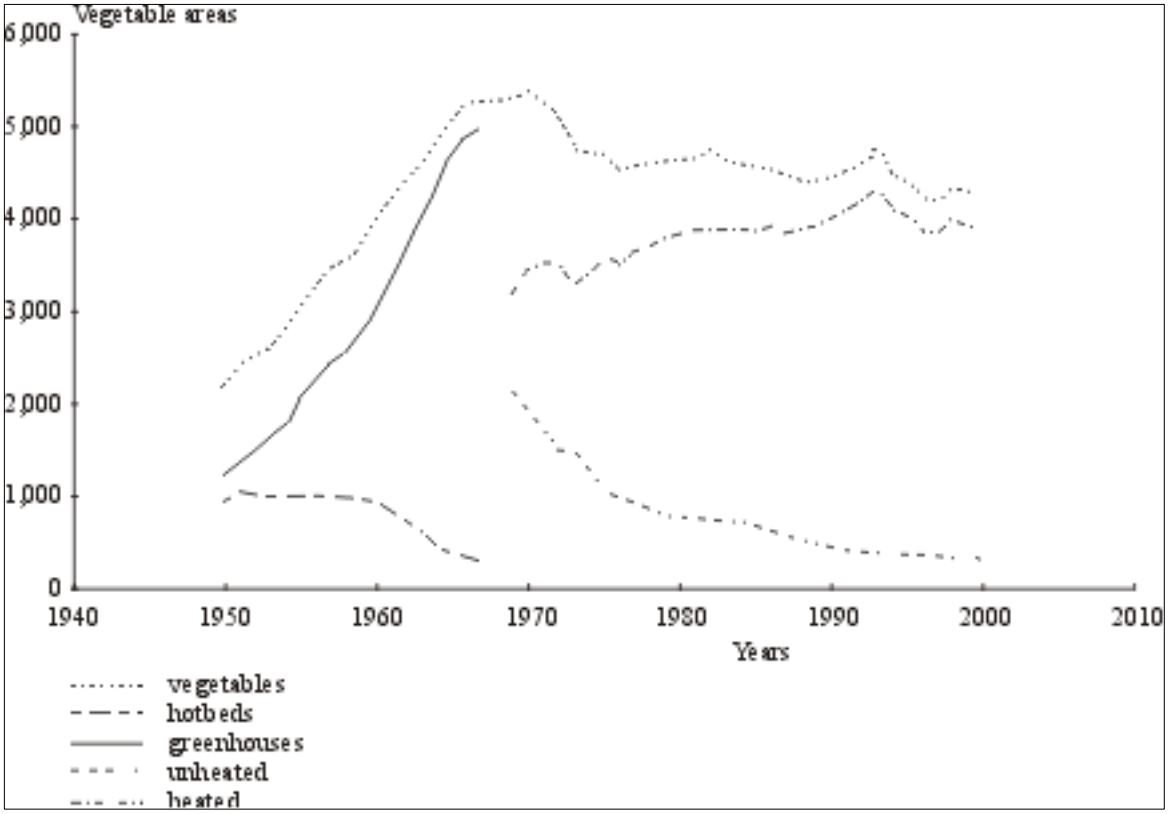


Figure 3.2 Evolutions within the greenhouse vegetable sector in the Netherlands

Until 1960 the vegetable area included about 1,000 ha of hotbeds. Soon after, this type of 'greenhouse' disappeared. In 1969 about 40% of the vegetable area (about 2,000 ha) was unheated. In 1980, however, this type of vegetable production occupied only 800 ha. Further reductions occurred, resulting in an area of about 300 ha in 2000. On the other hand, the area of heated greenhouses gradually increased and reached a maximum of 4,350

ha in 1993. Afterwards the area concerned stabilized at a level of about 3,900 ha. Figure 2 shows the gradual change from hotbeds to greenhouses and from unheated to heated greenhouses. The reduction in the total area of greenhouse vegetables can be attributed to the reduction in the area of unheated greenhouses.

Greenhouse floriculture

Figure 3.3 shows the changes in the greenhouse floriculture sector.

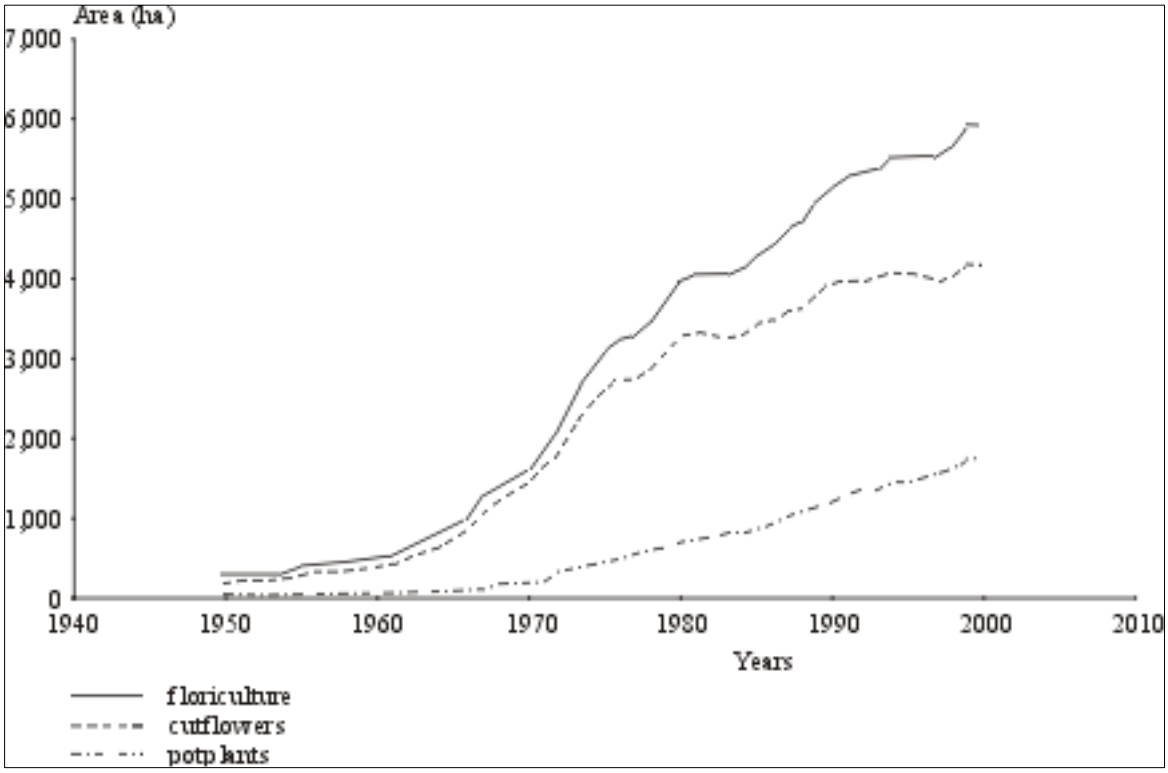


Figure 3.3 Changes in the greenhouse floriculture sector in the Netherlands

The floriculture sector underwent tremendous growth from 1965 onwards. In the period 1965-1980, the cut flower area expanded very rapidly from 750 ha to 3,250 ha. From 1980 onwards the growth rate of the cut flower sector declined and the area stabilized at a level of 4,000 ha. On the other hand, the pot plants sector went on expanding, to reach 1,750 ha in 2000. The trend of pot plants having an increasing part in floriculture also implies an intensification.

Successive lifecycles

Starting from the development patterns in the preceding sections, the following development periods can be distinguished:

Period	Fruits	Vegetables	Cut flowers	Pot plants	Trees
1945-1965	Declining	Expanding			
1965-1980	Declining	Stabilizing	Expanding		
1980-1993		Stabilizing	Expanding	Expanding	
1993-2000		Hesitating	Stabilizing	Expanding	Expanding

In the period 1945-1965 the vegetable area expanded very rapidly, while fruit growing in greenhouse was already on the decline. In the period 1965-1980 the cut flowers area expanded very rapidly. Simultaneously, the vegetable area stabilized and fruit growing became an exception. In the period 1980-1993, the cut flower area expanded less rapidly, pot plants became more and more important, and the area devoted to vegetables remained unchanged. In the period 1993-2000, expansion moved away from cut flowers in favour of pot plants and nursery trees, and the vegetable sector underwent a slight decline.

Physical yields

The evolution of greenhouse areas over the past decades only gives a superficial view. Inside the greenhouse several technological innovations were applied. Some examples of intensification were indicated in Figure 3.2. The innovations resulted in, amongst other things, increasing physical yields. In Figure 3.4 the physical yields of the three most important greenhouse vegetables (tomatoes, cucumbers, sweet peppers) in the Netherlands are presented.

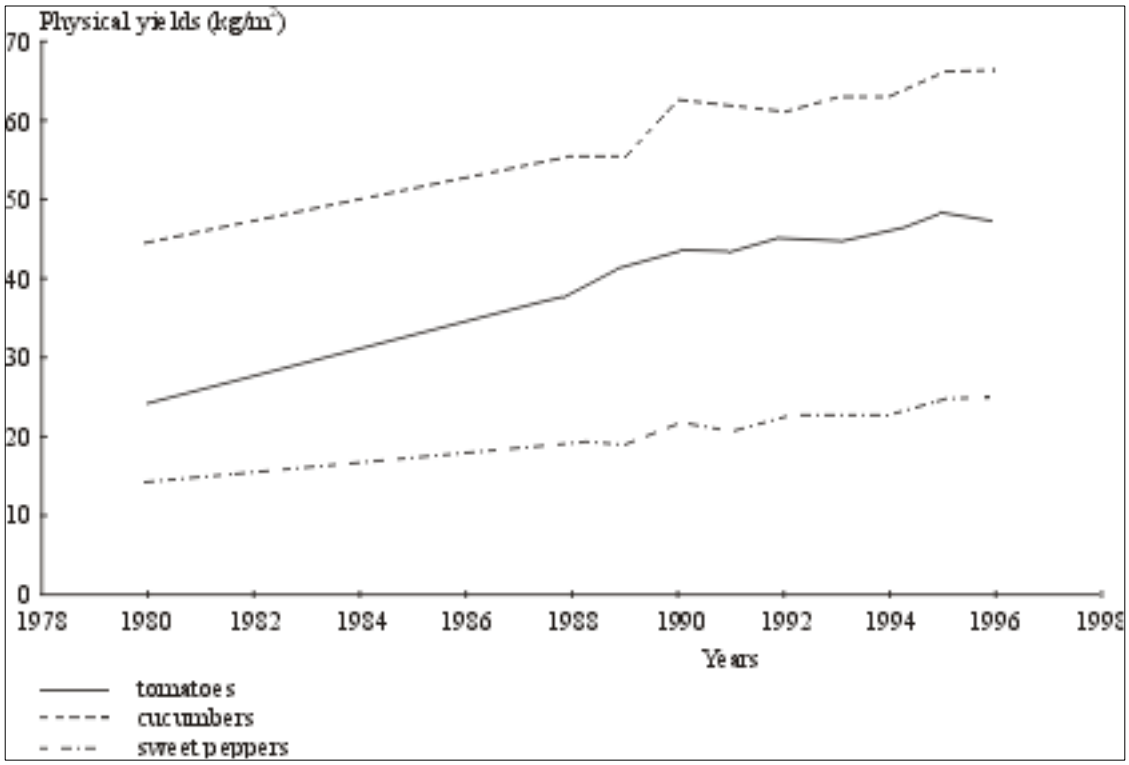


Figure 3.4 Evolution of physical yields (kg/m^2) of three vegetable crops in the Netherlands

The figure covers the period 1980-1996. During this period the yields of cucumbers rose from 45 kg/m^2 in 1980 to 66 kg/m^2 in 1996, an increase of 47% in 16 years. In the same period, the physical yields of tomatoes nearly doubled from 24 kg/m^2 to 47 kg/m^2. For sweet peppers a similar pattern is applicable with physical yields rising from 14 kg/m^2 in 1980 to 25 kg/m^2 in 1996, an increase of 79% in 16 years.

For tomatoes, the time series can be reconstructed back to 1954. In that year, the physical yield of tomatoes amounted to 8 kg/m^2. Intermediate levels were 10 kg/m^2 in 1963 and 15 kg/m^2 in 1975. Together with 24 kg/m^2 in 1980, 38 kg/m^2 in 1988 and 47 kg/m^2 in 1996, the progress in tomato production was more than respectable.

Figure 3.5 shows the evolution of physical yields in roses and chrysanthemums.

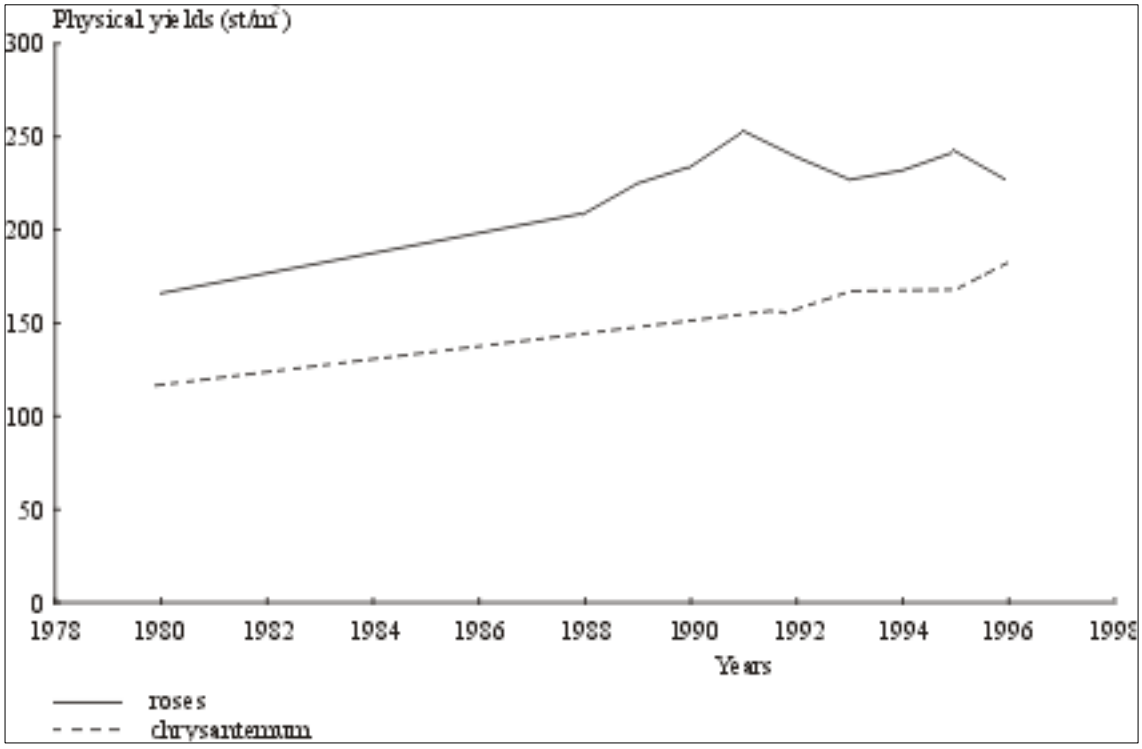


Figure 3.5 Evolution of physical yields (stems/m^2) of two cut flowers crops in the Netherlands

The figure shows a similar pattern for cut flowers as that shown for vegetables. The physical yields of roses increased from 166 stems/m^2 in 1980 to 226 stems/m^2 in 1996, an increase of 36% in 16 years. The fluctuations in stems/m^2 are related to shifts between small-flowered and big-flowered varieties. Both types are mixed up in the time series.

The physical yields of chrysanthemums rose from 117 stems/m^2 in 1980 to 183 stems/m^2 in 1996, an increase of 56% in 16 years.

The increasing physical yields of greenhouse vegetables and crops are the result of a complex of gradual improvements in length of growing season, light transmission of

greenhouses, climate control, nutrient management, and appropriate varieties. More information on these improvements is given in Section 4.

Labour productivity

In the previous sections, crop productivity was considered. The following section gives an impression of improvements in labour productivity. This is based on a figure from exemplary research in the period 1965-1980. In that period, labour productivity was a hot issue in technical and economic research, because of the rapidly rising wages in the period concerned. Figure 3.6 shows the relationship between farm size (X axis) and task size (Y axis). The basic data come from cut flower holdings in the Farm Accountancy Data Network (FADN) of LEI.

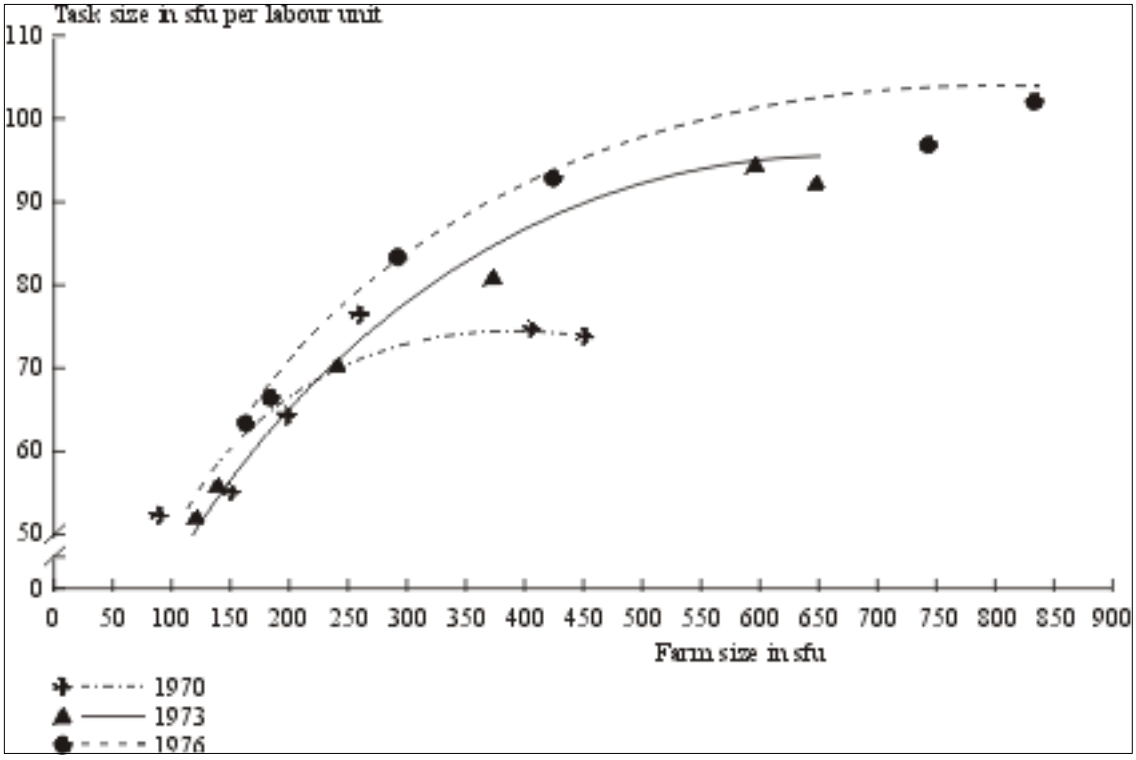


Figure 3.6 The relationship between farm size (X axis) and task size (Y axis)

Figure 3.6 shows the relationship between farm size and task size at cut flower holdings for 1970, 1973 and 1976. The polygons for the three years show that the bandwidth of farm sizes changed from 100-450 sfu[1] in 1970 to 150-850 sfu in 1976. This implies that cut flower holdings rapidly expanded their production sizes during the period concerned. Furthermore the figure clearly shows an impressive increase in labour

[1] sfu= standard farm unit; a unit to measure the economic size of a farm, based on net value added.

productivity from 75 sfu per man-year in 1970 to 100 sfu per man-year in 1976 at the biggest holdings. On the smaller holdings, the increase in labour productivity was relatively small.

The explanation for increasing production size and labour productivity can be found in mechanization. In the period 1965-1980 all kinds of machinery and equipment were introduced to save labour, e.g. for climate control, for harvesting and grading, for heating (switch to natural gas). Time-consuming activities like plant raising were contracted out to specialized partners.

Objective

The goal of increasing crop productivity (kg/m^2) and labour productivity (h/m^2) was to reduce the costs per kg of product. Increasing crop productivity involves higher fuel costs and equipment costs per m^2 of greenhouse, but not per kg of vegetables or per cut flower. The same applies to labour productivity. Mechanization involves higher costs of equipment per m^2, but not per kg of vegetables or per cut flower.

Table 3.2 gives a time series of the main cost components per kg tomatoes.

Table 3.2 Costs of main inputs (guilders per kg) for tomatoes in the Netherlands in a series of years

Cost component	1954	1958	1963	1969	1975	1982
Fuel costs	0.44	0.35	0.36	0.39	0.24	0.54
Fixed assets costs	0.37	0.36	0.36	0.32	0.33	0.44
Labour costs	0.21	0.20	0.21	0.28	0.38	0.53
Total (in nominal guilders)	1.02	0.91	0.93	0.89	0.95	1.51
Index purchasing power NLG	435	370	323	233	137	90
Total (in 1980 guilders)	4.44	3.37	3.00	2.07	1.30	1.36

Table 3.2 shows that the costs (in nominal guilders) of the main inputs did not increase between 1954 and 1975. In the period 1975-1982, however, inflation was so high that increased productivity could not compensate for it. Expressed in 1980 guilders, the main costs per kg tomatoes sharply decreased from 4.44 in 1954 to 1.36 in 1982. This price decrease gave Dutch tomatoes a very strong competitive position in Western Europe, thus resulting in extensive export opportunities.

4. Technical and institutional developments by period

In this section the technical and institutional developments behind the statistical data (presented in the previous section) are explained. For that purpose four successive periods are considered, each representing a specific phase in the development path:
- 1945-1965: reconstruction;
- 1965-1980: mechanization;
- 1980-1993: computerization;
- 1993-2000: integration.

The information concerned has been largely extracted from the memorial volume *One Hundred Years of Applied Research in Greenhouse Horticulture*.

In each period four dimensions are considered: (1) yield, (2) labour, (3) knowledge and (4) marketing. The first two dimensions represent the technical developments, the last two the institutional developments.

4.1 1945-1965: reconstruction

In the period 1945-1965 the greenhouse sector had to recover from the hardships of World War II. The purchasing power of the consumer in north-west Europe was weak, and materials for construction or production purposes were hardly available. As a result, reconstruction started off very slowly. In the course of years, however, the process gained speed. Consequently, the section concerned in *One Hundred Years of Applied Research in Greenhouse Horticulture* was entitled 'From slow recovery to high prosperity'.

Table 4.1 Key words for technical and institutional development in the period 1945-1964

Yield	*Labour*
improved fertilization	hotbeds >> greenhouses
growth regulation	hose watering >> sprinklers
pest/disease control	canal transport >> road transport
improving varieties	potting soil: own >> ready to use
Knowledge	*Marketing*
extension = troubleshooter	cooperative auctions
research = problem-solver	meeting place for growers
diagnosis pests and diseases	market information
growers' study groups	fundraising for research

The specific developments in this period are summarized in Table 4.1. The table shows the developments in two technical dimensions (yield and labour) and in two institutional dimensions (knowledge and marketing).

Yield

The yield dimension of Table 4.1 shows improved fertilization, growth regulation, pest/disease control and improving varieties as the major fields of attention. In the period of reconstruction, soil analysis became an important tool to give growers an impression of the nutrient status of their topsoil. Thus the growers adjusted nutrient management to the specific needs of their crops. Furthermore, profile examinations were implemented to give growers an impression of the suitability of their soil for horticultural production. These examinations were practised particularly in case of the purchase of new land. In addition, extensive research programmes, both on-farm and on-station, were launched for the development of fertilizer recommendations.

Furthermore, the government invested in infrastructure to provide greenhouse areas with good irrigation water. Salt from the North Sea and the Rhine threatened to make surface water useless for irrigation purposes in the greenhouse district of South Holland. For that reason surface water salinity was closely monitored by the research stations for greenhouse horticulture. Another development was the establishment of an advisory service for producers of potting soil. They were given advice on the best composition and nutrient status of potting soils for various plants.

Fruit set in tomatoes was a problem during the winter months. Research and practice tried to solve the problem by using growth regulators. Nevertheless, crop management remained problematic in the winter season. Use of truss vibrators significantly reduced the fruit set problem. Furthermore, several techniques were tried to limit root growth in order to improve truss formation. Finally, light intensity in the greenhouse turned out to be a crucial factor for fruit set. This finding became an important reason for designing greenhouses with higher light transmission rates.

Pest and disease control received much attention in the reconstruction period. The major problems were tomato mosaic virus (TMV), Fusarium oxysporum in carnation, virus diseases in carnation and chrysanthemum, Phytophthora in gerbera, Sphearotheca in roses, and Cylindrocarpon in cyclamen. These problems were studied one by one by researchers or crop specialists. The rate of acceptance by the growers was in most cases very high. TMV in tomatoes was in the first instance solved by inoculating the plants with a weak variety of the virus. Fusarium in carnation was conquered by switching to less susceptible varieties. The virus problems in carnation and chrysanthemum were solved by cleaning the planting material through meristem culture. Phytophthora in gerbera was suppressed by soil disinfection or soil steaming. Sphearotheca in roses was controlled by sulphur applications, in the beginning as powder and later as vapour. The problem of Cylindrocarpon in cyclamen was solved by growing seedlings in steamed soil.

Simultaneously, several kinds of variety trials were implemented at the research stations. At the research station for floriculture, one greenhouse was used for presenting all kinds of less known plants to trainees. At the research station for greenhouse vegetables, large numbers of new cultivars of various crops were compared. Furthermore, new kinds

of vegetable crops were introduced in order to diversify the assortment of vegetables. The variety trials were in many cases implemented in cooperation with breeding companies and growers' associations.

The conclusion from the previous sections is that yield improvements were obtained by removing practical weaknesses and threats regarding soil fertility, plant protection and variety characteristics. This was done by means of close cooperation between growers, advisers and researchers. Thus yields at the growers' level were increased step by step.

Labour

The labour dimension in Table 4.1 shows various switches, each of which saved the growers considerable amounts of labour, i.e. the switch (1) from hotbeds to greenhouses, (2) from hose watering to sprinkler irrigation, (3) from canal transport to road transport, and (4) from own produced potting soils to ready-to-use potting soils.

The switch from hotbeds to greenhouses brought about an enormous improvement in labour productivity and labour conditions. With hotbeds, all operations are implemented from outside; consequently, the frames have to be opened and closed for each operation. In greenhouses, all operations are implemented from inside; consequently, the handling of the frames was saved. Moreover, the workers could reach the plants much more easily. Thus labour conditions and labour performance strongly improved. The hotbeds soon disappeared, after research had demonstrated that crop growth in greenhouses was as good as in hotbeds.

The switch from hose watering to sprinkler irrigation improved the productivity of both labour and crops. With sprinkler irrigation, the labourers had to spend less time on watering and the water was more evenly distributed among the plants. Consequently, sprinkler irrigation led to higher yields and lower labour use. The switch to sprinkler irrigation was supported by research. Various watering methods were compared and the water needs of the different crops were established.

The switch from canal transport to road transport strongly improved the transport to and from the greenhouses. In 1958 more than 40% of greenhouses were accessible only by boat or on foot. This represented an enormous obstacle to smooth transport. Research stations and extension played an important role in opening up Westland. Greenhouses and growers had to make room for road construction. This radical process was guided by the extension service, which acted as a mediator between the parties with conflicting interests.

The switch from own produced potting soils to ready-to-use potting soils saved the growers the time required to collect the raw materials and the risk of producing a poor quality soil. Analyses carried out by the research stations showed that about 70% of own mixtures were far too saline for growing good plants. Subsequently the research stations spent a lot of time establishing the optimal composition of potting soils for different crops. The production of potting soils was gradually transferred to specialized enterprises. The research stations developed an advisory and certification system for the potting soil sector. This system finally resulted in a national certification body for potting soils. The advantage of this system is the higher quality of the ready-to-use potting soils and the consequent higher crop productivity.

The conclusion from the previous sections is that technical improvements resulted in both lower labour use and better labour conditions. In some cases, crop productivity was also improved. The introduction of the technical improvements was in all cases guided by research and development activities. Thus again there was good cooperation between growers and knowledge institutions.

Knowledge

The knowledge dimension of Table 4.1 shows in key words what extension and research did in the period 1945-1965, i.e. troubleshooting and problem-solving, respectively. They also spent a lot of time diagnosing pests and diseases. Furthermore, there arose a new phenomena in the knowledge system: study groups comprised of growers.

The explanations under 'yield' and 'labour' already made clear that research and extension were closely involved in the innovation processes in greenhouse production. They supported new developments by picking up current problems and generating knowledge about the newly introduced techniques. These efforts were made in close cooperation with breeding companies and growers' associations.

The close relationships within the knowledge system were supported by organizational linkages between research, extension and education. The three subsystems had one and the same person as director. Consequently, information circuits between research and extension were very short. What the director heard yesterday in his extension function he could propagate today in his research function, and vice versa. Furthermore, research and extension people participated in each others meetings.

Simultaneously, extensionists and researchers worked together as colleagues. They were equal to each other and the boundary between research and extension was not fixed: extensionists participated in trials, and researchers participated in farm visits. This was a very stimulating atmosphere for both research and extension.

In line with this open atmosphere, the growers' study groups developed well. They played an important role in the dissemination of horticultural knowledge. In winter they organized meetings at which researchers and extensionists presented and discussed current technical and economic issues. During the growing season, the groups compared new varieties and cropping systems in practical trials and organized excursions to innovative growers and enterprises, also abroad. Most study groups developed thanks to the hospitality of the auctions.

The conclusion from the previous sections is that knowledge development flourished quite well in an open atmosphere of researchers, extensionists and growers' study groups. The three stakeholder groups cooperated as real colleagues, resulting in a high level of team spirit. This team spirit was strongly supported by organizational linkages (same director, common meetings) between the three groups.

Marketing

The marketing dimension of Table 4.1 is characterized by such key words as cooperative auctions, meeting place for growers, market information and fundraising for research. This

set of key words makes it clear that the auctions played an important logistic role in the development of greenhouse horticulture.

The functions of the auction were broader than just being a selling place for horticultural produce. Most growers brought their products nearly every day to the auction. Consequently, the auction developed into an important meeting place where growers could access market information and exchange technical experiences. Starting from this tradition, the auctions offered to host the study groups.

The auctions further play a crucial role in the financial transactions between growers and traders. They guarantee the growers payment for their products (traders are not allowed to transport their products before providing the auction with a payment guarantee). Consequently, the growers need not wait for the money from the traders.

Because of the crucial position in the financial transactions, the auctions were asked to withhold a small percentage of each grower's sales to finance further research. Thus the knowledge system and the marketing system are also interlinked.

The conclusion of the previous sections is that the auctions played a crucial role in the development of the greenhouse sector. Firstly by guaranteeing the growers that they would get paid for their products; secondly by providing an implicit and explicit meeting place for the growers to exchange information and experiences (via study groups); and thirdly by raising funds for research. Consequently, knowledge and marketing are interlinked by the auctions.

4.2 1965-1980: mechanization

In the period 1965-1980 wages increased very rapidly owing to unprecedented economic growth in Western Europe. This had a large impact on both the production and consumption of horticultural products. On the production side, mechanization compensated for the increasing wages. On the consumption side, the demand for flowers and pot plants increased strongly. The foundation of the European Economic Community (EEC) led to the abolition of growing licences for floriculture, a leftover from the crisis period before World War II. The above-mentioned factors together resulted in high growth rates for greenhouse floriculture. All in all, greenhouse horticulture got a completely new look in the period under consideration.

The specific developments in this period are summarized in Table 4.2. Subsequently the following dimensions are reviewed: yield, labour, knowledge and marketing.

Table 4.2 Key words for technical and institutional development in period 1965-1980

Yield	*Labour*
interplanting >> longer season	heating: coal >> oil >> gas
unheated >> heated greenhouses	plant raising: own >> contracted
improving climate control	mechanization climate control
improved planting material	mechanization harvesting/grading
Knowledge	*Marketing*
combine practice and government	liberalization EU market
research efforts for input industry	sales promotion by auctions
energy saving programmes	market research by auctions
demonstration project 'Denarkas'	fundraising for research

Yield

The yield dimension of Table 4.2 shows interplanting, heating, climate control and planting material as the major fields of attention. In tomatoes, problems with TMV (tomato mosaic virus) reduced fruit set and fruit quality. Solutions from research and plant breeding were instantly picked up in practice. The solutions were to infect seedlings with a weak variety of the virus and to grow TMV-resistant varieties. The introduction of TMV-resistant varieties had a much greater impact on tomato growing than researchers had foreseen. In the old situation, the greenhouse was cleaned in the summer to prevent the virus from being transmitted from the spring crop to the autumn crop. With TMV-resistant varieties, separation of the two crops was no longer necessary and intercropping was the result. Consequently, continuous harvesting from March up to October became possible and physical yields increased considerably. Simultaneously, tomato production in unheated greenhouses (with harvesting in summer) lost his niche in the market and growers were forced to switch to other cropping systems or to crops with better economic prospects.

Physical yields in the pot plants sector improved through the introduction of roller tables and concrete floors. The numbers of plants per m^2 of greenhouse increased considerably through application of these techniques, as did the crop productivity of the greenhouses.

In the period 1965-1980, many growers switched from unheated to heated production in order to achieve higher physical yields. This development was further stimulated by the introduction of natural gas as a new source of energy. Natural gas is much easier to handle than coal or oil. Moreover, it brought the production of good quality CO_2 within the reach of the individual grower. On-station and on-farm research had already demonstrated that the application of carbon dioxide considerably increases yields. Consequently, the switch to heated production resulted in two yield effects: (1) the effect of higher growing temperatures, and (2) the effect of higher CO_2 levels.

Owing to the introduction of electric motors, ventilation in greenhouses could be mechanized. Research stations developed climate control systems to adjust ventilation to temperature and humidity in the greenhouse. The systems were based on the practices and

experiences of leading greenhouse growers. Also the heating system was adjusted: smaller heating pipes were introduced to facilitate the possibilities for a quick adjustment to short-term weather changes, and the heating pipes in the greenhouse were moved from gutter level to floor level. The latter adjustment also reduced the amount of shadow in the greenhouse. Various investigations had shown that 1% more light in the greenhouses resulted in 1% more production.

The efforts made to improve climate control had three purposes: to save labour, to save energy and to increase yields. Energy saving became an important point of attention through the sharply increasing energy prices caused by hostilities in the Middle East in 1973 and 1979. Many research activities were started to cut the energy costs at production level. In addition a demonstration project (Denarkas) was started in 1980. Three types of greenhouses (each 3,300 m^2) were compared in this project.

Lettuce was an important greenhouse vegetable product in the period 1965-1980. In the 1960s, the use of bare-rooted transplants was most common. Single harvest is impossible with this system because of the heterogeneity in plant development. For that reason the growers switched to soil block transplants. Simultaneously, the soil block machine and application of pelleted seed were introduced. This combination of innovations facilitated the mechanized production of planting material, resulting in a homogeneous product and the advantages of single harvest.

Tissue culture became popular in floriculture for the rapid propagation of disease-free planting material. Consequently, most pot plant growers discontinued the propagation of planting material. Owing to falling product prices for vegetables, the sector started growing such 'new' products as paprika, aubergine and radish. The assortment in the cut flower sector underwent only small adjustments. In the pot plants sector, the share of foliage plants strongly increased to meet consumer preferences.

Labour

The labour dimension in Table 4.2 shows four labour saving developments: switch to natural gas heating, contracting out of plant raising, mechanization of climate control and mechanization of harvesting and grading. Another innovation was the switch from clay pots to plastic pots in pot plant production. Switching to natural gas saves having to transport oil and – owing to less pollution – the frequent washing of greenhouse roofs.

Traditional plant raising at the farm level could no longer compete with modern plant raising by specialized and mechanized nurseries. For that reason most growers discontinued plant raising and started contracting out the activity to specialized nurseries.

In carnation production, a shift was made from single carnations to raceme carnations, marking the end of the labour-intensive disbudding work in carnations.

Until 1960, climate control was performed by hand in most greenhouses. The introduction of electric motors and analog climate control systems saved the grower considerable amounts of labour and resulted in a more steady climate in the greenhouse.

Much research was focused on labour studies. These studies aimed at gaining a better understanding of labour use and options for improvement. The majority of these studies were related to harvesting and processing activities. Different cropping systems and methods of harvesting and grading were evaluated from the viewpoint of labour use. Most

labour studies were implemented in practice and resulted in labour budgets for all kinds of operations. Using these budgets, the growers were able to compose the best working methods for their specific situation.

The switch from clay to plastic pots enabled mechanization in the pot plants sector. It was also important for water/nutrient supply and farm hygiene. Before the switch, the pots were placed into a layer of potting soil to prevent them from drying out and to ensure a supply of nutrients. This layer of soil then had to be steamed or disinfected to prevent diseases from contaminating the next batch of pot plants. With the introduction of plastic pots, the layer of potting soil was replaced by a thin layer of sand. This saved much labour and made the greenhouse benches much cheaper.

Knowledge

The knowledge dimension in Table 4.2 show as key words combining interests of practice and government, research for input industry, energy saving and Denarkas. Research, extension and education had strong relationships in the period under consideration. The relationship was characterized by the metaphor of the triptych. In the beginning the three functions were managed by one director. Consequently, researchers, extensionists and teachers were involved in all functions and thus knowledge exchange was very intensive. In later years education was made 'independent', but the interrelationships between research and extension were maintained. The director of the triptych also had many contacts outside the knowledge system. He was a major advisor to both the government and the greenhouse industry. Consequently, the different interests were smoothly combined or adjusted. Policy and practice had common targets and helped each other to meet those targets, resulting in a very strong competitive position. The cooperation between government and industry was further consolidated by 50/50 financing of the research stations. In addition, researchers from the research institutes of the agricultural research department were posted at the research stations. The aim of this was to create linkages between research and practice.

The target group of the research stations gradually changed between 1965 and 1980. Owing to mechanization and specialization, the input industry became a major stakeholder in the knowledge system. Plant nurseries, greenhouse constructors and mechanization firms became the primary utilizers of research results. These 'intermediates' incorporated the research results into their products and thus contributed to the dissemination of research findings to the growers. This conclusion applies to major parts of the dimensions yield and labour in Table 4.2. The labour studies are an exception to this rule.

Energy saving was an important subject in the second half of the period 1965-1980. The research stations put a lot of effort into developing energy saving options, like decreasing greenhouse temperatures, climate control options, insulation of greenhouses via energy screens, double-glazing or structured sheets, positioning and sizing of heating pipes, etc. This field of work is a good example of cooperation between government and industry for their mutual benefit. The results were incorporated into the product of greenhouse constructors and thus reached the growers.

Another milestone in the energy saving trajectory was the demonstration project Denarkas, which was jointly financed by the Ministries of Agriculture and Industry,

Rabobank (agricultural bank), Gasunie (gas/oil company) and the provincial government of South Holland. This list of co-financiers again reflects the resoluteness of both public and private sectors to overcome the energy problem in the greenhouse industry. The staff required to design and guide the project was provided by research stations and institutes.

Three greenhouse types were compared in the demonstration project. The objective was to adjust the growing systems as well as possible to the different growing conditions in the three greenhouses. Growers showed keen interest in the results. Over the course of the years, the objective was broadened from saving energy to bringing about sustainable production.

Marketing

The marketing dimension of Table 4.1 is characterized by the key words liberalization of EU market, sales promotion by auctions, market research by auctions and fundraising for research (also by the auctions). These key words make it clear that the auctions continued to play their important logistic role in the development of the greenhouse sector.

The market for horticultural products received a robust impulse through the liberalization of the EU market. The market for vegetables was liberalized in 1964 and the market for ornamentals in 1968. Simultaneously, the system of growing licences for floriculture was abolished in 1967. These institutional changes explain the rapid area increases for cut flowers and pot plants in the period 1965-1980.

The process of market expansion was accompanied by sales promotion and market research performed by the auctions. Furthermore the auctions continued raising funds for research by withholding a small percentage of each grower's sales.

4.3 1980-1993: computerization

The computer was introduced into greenhouse horticulture in the period 1980-1993. This provided several new options for climate control, nutrient management and information management. The optimization of crop management and of farm management were the key words, again resulting in higher physical yields and higher labour productivity. Consequently, crop production became more and more an industrial process, which was not fully appreciated by all interest groups.

The specific developments in this period are summarized in Table 4.3. The table shows four dimensions (yield, labour, knowledge and marketing), which are successively considered in the next sections.

Table 4.3 Key words for technical and institutional development in period 1980-1993

Yield	*Labour*
artificial substrates	transport systems
trickle irrigation	year-round production
CO_2 application	pollination >> bumble bees
shadow reduction	automatic roof cleaning
Knowledge	*Marketing*
climate control	increasing competition
biological pest control	mergers of auctions
management information	management data for growers
management support	environmental consciousness

Yield

The yield dimension of Table 4.3 shows artificial substrates, trickle irrigation, CO_2 application and shadow reduction as the mainsprings behind the yield increase in the period under consideration. Most of these techniques came within reach of the grower through the introduction of process computers. The process computer was needed to control the supply of nutrients, water and CO_2 to the crops in the greenhouse.

Before 1980 vegetables and flowers were grown in the greenhouse soil. Owing to the monoculture of many greenhouse crops, problems with soil-borne diseases were hard to control. The switch to substrate culture prevented the occurrence of soil-borne diseases. Furthermore substrate culture resulted in computer controlled nutrient management. The combination of fewer soil-borne diseases and improved nutrient management resulted in considerable yield increases. Increases of 15% were no exception.

The switch to substrate culture was accompanied by the switch to trickle irrigation. The latter innovation enabled conversion to computer controlled water management. Consequently, water supply was adjusted to the calculated water needs of the plant.

Water quality (clean and salt-free) became an important point of attention in substrate culture. Consequently, collecting runoff from the greenhouse roof in water basins or water tanks became popular. The improvements in water quality and water supply contributed greatly to the yield increase mentioned in the previous section.

Computerization also enabled improvements in CO_2 application. Application could now be closely adjusted to the fluctuations in the greenhouse. The problem, however, was how to balance CO_2 production and CO_2 consumption in summer, when consumption by the crop is high and production by the boiler is low. The solution was found in heat storage in large hot-water tanks. In this system the heat associated with CO_2 production in the daytime is stored and then used to heat the greenhouse at night. This innovation made the application of CO_2 more profitable and more common, and resulted in higher yields.

Research in earlier years showed the importance of light intensity in the greenhouse for crop productivity. This resulted in the rule of thumb that 1% more light = 1% higher yield. Consequently, constructors designed greenhouse roofs with higher light transmission

by narrowing gutters, ridges and bars on the one hand and widening glass panels. By doing so, light transmission rates have increased from 67% in 1980 to 75% in 2000.

Labour

The labour dimension in Table 4.3 shows four labour saving developments: transport systems, year-round production, pollination by bumble bees and automatic roof cleaning. In fruit vegetable production, the radiator tube rail system was introduced. In this system the radiator tubes on the greenhouse floor are used as rails for transport carts. Consequently, the labour hours for transporting the harvested product from the greenhouse considerably decreased and the transport work became less exhausting. Furthermore, the radiator tube rail system enabled the introduction of the high-wire system, which in turn resulted in a better product quality.

Another innovation was the introduction of assimilation lighting in the production of roses and other cut flowers. Through assimilation lighting, the production pattern and matching labour needed for cutting shows more regularity, resulting in a higher labour productivity. Simultaneously, the product quality improves. In fruit and vegetable production, bumble bees were introduced for pollination. The insects replaced the many hours of labour needed to promote fruit set. Pollination by bumble bees turned out to be much more effective than hand work. The result was a higher crop yield of better quality for lower labour costs.

Greenhouse roofs are cleaned several times a year in order to improve light transmission. Roof washing machines were introduced to reduce the harmful effects on the environment of chemical cleaning. Through the introduction of machines with rotating brushes, the work was largely automated.

Knowledge

The knowledge dimension of Table 4.3 shows climate control, biological pest control, management information and management support as the main subjects. The climate computer was the big control surprise of the period under consideration. Researchers, growers and advisors held extensive discussions in order to unravel the relationships between climate conditions and crop growth. The triptych of research, extension and education worked full speed for the benefit of the sector. The introduction of the climate computer was further stimulated by government subsidies. These subsidies had the objective of reducing energy use in the greenhouse sector.

The intensive use of pesticides for pest and disease control resulted in public concerns and protests by interest groups. The growers had a positive attitude towards the reduction of pesticide use, because they recognized the detrimental effects on their own health. The desire to reduce pesticide use was a strong stimulus to switch to biological pest control, in particular for insects and mites. The research stations played an important role in the development of biological control and integrated pest management. The introduction was further supported by the introduction of tracing and tracking systems by the auctions.

Computers also offered opportunities for technical record keeping. The growers already had a tradition of documenting technical data for decision-making purposes. They

kept records of yields, labour use, nutrient use, water use, energy use, etc. The findings were compared and discussed in study groups and the lessons learned were applied in the next planning cycle. The computer facilitated electronic data exchange and complex data-processing. Consequently, unprecedented opportunities for monitoring and evaluation of climate conditions, energy use, labour use, yield patterns, product prices and so on came within reach. The national federation of study groups in horticulture installed a commission for farm monitoring. Starting with existing monitoring forms, they composed a standardized set of monitoring forms (the Green Book). The growers could utilize subsets of the Green Book for monitoring purposes. In the beginning data entry and data-processing were facilitated by the auctions. The resulting summaries were returned to the study groups for evaluation purposes. After some years, handwriting by the grower and data entry by the auction was replaced by electronic data exchange between grower and auction. Further developments resulted in a national databank/communication platform, managed by the national federation of study groups in horticulture. The databank involved is accessible to individual growers, study groups, research stations and other knowledge organizations. The introduction of farm monitoring was strongly stimulated by the national government, especially by the development of information models. These information models provided the conceptual basis for the development of information systems for farm management by the industry.

Next to information systems there is the manager who has to make the most of the world of information around him. A working group on management development was set up to improve the management level of the growers. Research by the working group showed a positive correlation between management level and economic performance. The working group made many recommendations for improving the management level in horticulture. Also a checklist for detecting strengths and weaknesses in the grower's management was developed.

Marketing

The marketing dimension of Table 4.3 shows increasing competition, mergers of auctions, management data for growers and environmental consciousness as the major fields of attention. At the end of the period 1980-1993 the prices of greenhouse vegetables were under strong pressure. Increasing supplies from Spain and Morocco depressed prices in north-west Europe. In the euphoria following the fall of the Berlin Wall, production expanded considerably. However, the purchasing power in central Europe proved to be smaller than many people had hoped. Moreover, the image of Dutch greenhouse vegetables was on his return (water bombs).

A major development in this period was the emergence of big supermarket chains disturbing established relationships between supply and demand. They started pushing individual auctions to meet their product specifications and nothing else. This was a new phenomena for the auctions. In the first instance they reacted with mergers in order to restore the mutual competition among the supermarkets. On the other hand they started experiments with price/supply negotiations through agencies. At the same time, the supermarkets started signing production contracts with individual growers.

The auctions played an important role in providing their members/growers with management information. They supplied services for entering and processing the monitoring data provided by the growers/members of study groups. The aim behind this was to strengthen the competitive position of the Dutch greenhouse sector and to obtain information on production practices for marketing purposes.

The auctions reacted to the public's concerns and protests over the pollution of the environment by nutrients and pesticides. Actually the whole production system with use of substrates and computers had resulted in an industrial image which was condemned by several interest groups (especially in Germany, the main export destination). The auctions therefore installed tracing and tracking systems. The growers were stimulated to keep records of nutrient and pesticide usage. Environment unfriendly practices were not allowed within these systems. In the vegetable sector the products grown under the system were given a special label: a butterfly. The introduction of this label was followed by an extensive and expensive publicity and promotion campaign intended to illustrate the environmental consciousness of the greenhouse sector.

The conclusion of the previous sections is that the marketing of greenhouse vegetables was problematic at the end of the period under consideration. The power in the market had gradually shifted from the supply side to the demand side of the market. Moreover, the production system and the product quality was condemned by a large number of consumers.

4.4 1993-2000: integration

The last decades of the 20th century saw far-reaching changes in the organization of marketing and research. Consumer preferences became the major determinants of product quality and production methods. The auctions lost their monopolist position in the supply market, and several growers' associations were established to meet the needs of specific exporters and supermarkets. The knowledge system was reorganized. Many regional experimental gardens were closed. On the other hand, several commercial laboratories with specialist expertise emerged. The existing research stations and institutes acquired a more commercial position with regard to government and industry.

Table 4.4 Key words for technical and institutional development in period 1993-2000

Yield	*Labour*
productivity >> quality	team spirit
process certification	education
Knowledge	*Marketing*
pesticide reduction	growers' associations
energy saving	trade marks
agro-chain knowledge	'The Greenery'
privatization knowledge system	chain integration

Yield

The yield dimension in Table 4.4 shows just two subjects: the switch to product quality, and process certification. This indicates that the efforts of research and industry were less focussed on increasing physical yield. Instead, it was largely on improving product quality and process quality. The objective of these efforts was to gain more appreciation and higher prices from the market. A milestone in this conversion process was the Kearney Report (AT Kearney, 1994) which was significantly entitled 'Lost the market?'.

The tracing and tracking systems for nutrient and pesticide use were further developed into certification systems with third-party inspections.

Labour

The labour dimension in Table 4.4 also shows just two subjects: team spirit and education. Both show that the attention paid to technical methods for improving labour productivity was low in the period under consideration. Owing to shortages in the labour market, greenhouse growers had difficulties in keeping their labourers and recruiting new ones. Human resources management became an important issue. Teambuilding and education represent this development. One of the underlying thoughts here is that motivated personnel perform better; a very important condition for producing high-quality products.

Knowledge

The knowledge dimension in Table 4.4 shows pesticide reduction, energy saving, agro-chain knowledge and privatization of the knowledge system as the leading subjects. Food safety and human health became important determinants in the buying behaviour of the consumer, particularly when it came to greenhouse vegetables. Moreover, public concerns arose about the production system for greenhouse vegetables. Substrate culture was associated with pollution, industrial processes and bulk production. The government took responsibility and covenants were concluded with the industry on the reduction of pesticide use and energy use. Reduction rates of about 50% were agreed for both inputs. Many research and development projects were started to bring these ambitious reduction rates within reach. The implementation of the two covenants was supported by several governmental and sectoral regulations.

Special trade marks were introduced to meet the consumer's demand that both products and production processes should be safe. The objective of the trade marks was to guarantee the origin and the quality of the product. In many cases a trade mark was owned by a growers' association. Such associations made clear arrangements with exporters or supermarket chains concerning product supply, product quality and product prices. The growers' associations in many cases bypassed the auctions, because of the auctions' determination to maintain homogeneity in supply and to refuse diversity in pricing systems.

The development of trade marks was supported by the research stations through the development of quality management systems as a basis for certification.

The establishment of growers' associations marked the restructuring of supply chains. A foundation for agro-chain knowledge was established to improve cooperation between the chain partners. The foundation initiated many research projects to get product quality better adjusted to requirements for transport, processing and retailers. Agro-technology research became extensive in the period under consideration.

Simultaneously, the knowledge system was privatized. Firstly the extension service was privatized. The new organization had to stepwise increase the funds it received from private sources, such as growers, study groups and growers' associations. One of the problems the new organization faced was how to maintain a sufficient knowledge level. The growers were not satisfied in that respect, and therefore established their own organization to canalize the knowledge flow from research to practice. This service organization – LTO-Growservice – also facilitates the work of the study groups.

The research part of the knowledge system gradually shifted from input financing to output financing. This means operating on a contract basis. Consequently, the acquisition of contracts from public and private knowledge users became part of the game. This resulted in a more commercial approach within research institutes and research stations. Simultaneously, the commodity boards established a research coordination bureau in order to collect the research questions from practice, to translate them into research themes and to negotiate contracts with research institutes or stations. The process of research coordination is guided by programme advisory committees. These committees are comprised of stakeholders ranging from input suppliers to auction representatives.

Marketing

The major fields of attention in the marketing dimension of Table 4.4 are growers' associations, trade marks, 'The Greenery' and chain integration. In the period under consideration, the market for horticultural products changed from supply-driven to demand-driven. Henceforth the requirements and preferences of supermarkets and consumer interest groups could no longer be neglected. Growers' associations were established to meet the needs of exporters or supermarkets. The growers' associations introduced trade marks to protect their positions in the market.

The position of the vegetable auctions was no longer sovereign. The forces on the demand side of the market became stronger and stronger. In order to better meet the needs of the market, the majority of the existing vegetable auctions merged to become 'The Greenery International'. The new marketing organization developed new marketing concepts and no longer left price setting to the auction clock. Price negotiations with exporters and the buying departments of supermarkets became common. They thus developed from a market place into a marketing partner. The Greenery even bought some vegetable export and processing companies in order to shorten the supply chain and reduce the dependency of intermediate stakeholders in the chain.

Chain integration was the result of the foregoing developments in the marketing dimension. The market share of supermarkets in vegetable sales strongly increased at the expense of greengrocers and fresh markets. Consequently, there was a reduction in the number of supply chain partners (wholesalers and exporters) related to the latter outlets. Business-to-business contacts between growers/growers' associations and the buying

departments of supermarket organizations strongly increased. Cooperation in product development between producer and retailer became more and more common practice.

5. Assessment of the current position of horticulture in the Yangtze Delta

In this section an effort is made to position horticulture in the Yangtze Delta on the 1950-2000 time axis of greenhouse horticulture in the Netherlands. For this, a distinction is made between traditional production systems and industrial production systems. For both types, the key words from the report on the fact-finding mission to Shanghai (Buurma, Van Horne, Xiauyong, 2000) are gathered. Starting from the key words, the positioning on the above-mentioned time axis is made. In addition, some reflections on the technical and institutional implications are presented.

Traditional horticulture in 1960

During the mission to Shanghai in May 2000 several traditional production centres were visited on Chongming Island and in Wujiang district. The most important key words on horticulture on Chongming Island were:

- constructing greenhouses from local design;
- production know-how was traditionally available;
- variety testing is an important task of the station;
- main roads and drainage system have been completed;
- data on soil type, soil analysis, rainfall, etc. available.

In Wujiang district the key words characterizing local horticulture were:

- as well as camphor, 100 other species are grown (Taoyuan Town);
- in total 60-70 species are grown; (Wujiang City Plant Nursery)
- introduction of new species is important point of attention;
- watermelon production hampered by a wilting disease;
- rhododendron production hampered by fertilizer problems.

Many of these key words are also found in the yield and labour sections of Section 4.1 (1945-1965: reconstruction). Key words on mechanization, computerization or integration cannot be found in the reports on the visit to Chongming and Wujiang. This means that traditional horticulture in Yangtze Delta is somewhere in 1960 on the time axis of Dutch greenhouse horticulture. This date was also mentioned by an authoritative Dutch horticultural adviser who investigated the Chinese horticultural sector some years ago.

Industrial horticulture in 1980

During the mission, visits were also paid to the Shanghai Agriculture Industry and Commerce Group (SAICG) and the Sino Dutch Horticultural Training and Development Centre (SIDHOC). These organizations are representative of industrial horticulture in the

Shanghai area. The most important key words in the reports on the visit to these organizations were:

- experimenting with greenhouses from abroad;
- CO_2 application and artificial substrates too expensive;
- managers/technicians of larger companies with greenhouses;
- greenhouse constructors may come to copy constructions;
- production monitoring is completely lacking;
- an e-mail information system is badly needed.

This set of key words refers to the situation described in the yield and labour sections of Section 4.3 (1965-1980: mechanization). In this period, CO_2 application, artificial substrates and production monitoring were not employed in the Dutch greenhouse industry. It was a period of strong economic growth and increasing demands for flowers and pot plants in western Europe. Similar developments are now occurring in the Shanghai area. This means that industrial horticulture in the Yangtze Delta is somewhere in 1980 on the time axis of Dutch greenhouse horticulture.

Implications for traditional horticulture

In 1960 the key words for extension and research in the Netherlands were troubleshooting and problem-solving, respectively. They supported new developments by picking up current problems and generating knowledge about the newly introduced techniques. These efforts were made in close cooperation with breeding companies and growers' associations. The information lines between research and extension were very short. The boundary between research and extension was not fixed, and the distance between extension and growers was very short. Growers' study groups played an important role in the dissemination of horticultural knowledge. The three stakeholder groups (researchers, extensionists and study groups) cooperated as real colleagues, resulting in a high level of team spirit. The Chinese knowledge system should do its best to bring the three stakeholder groups closer together.

Implications for industrial horticulture

In 1980 the key words for research and extension were combining interests of industry and government, and research for the input industry. Policy and practice had common targets and helped each other to meet those targets, and this resulted in a very strong competitive position. Owing to mechanization and specialization, the input industry became a major stakeholder in the knowledge system. Plant nurseries, greenhouse constructors and mechanization firms became the primary utilizers of research results. These 'intermediates' incorporated the research results into their products and thus contributed to disseminating research findings to the growers. The Chinese knowledge system should intensify its cooperation with the input industry.

Implications for export horticulture

During the fact-finding mission, exporting to Japan and Singapore was frequently mentioned as an option for the Chinese horticultural sector. Exporting to Japan and Singapore implies compliance with the international standards of 2000. This means introducing certification systems and third-party inspections. It also means translation of consumer preferences in the countries of destination to product qualities and production systems in China. This will require a lot of market information and chain management. However, the Chinese knowledge system should intensify its cooperation with the export industry.

Opportunities for Dutch agribusiness

As mentioned in the fact-finding mission report of May 2000, the time of just selling hardware is over (SAICG) and foreign technologies do not work without adaptation to the local circumstances (SIDHOC). Consequently, the Dutch agribusiness sector should focus on exporting technical and institutional knowledge rather than technologies. This implies close cooperation with public and private partners in China. Depending on the target group (i.e. traditional or industrial horticulture) cooperation should start from the 1960 or 1980 development level of Dutch horticulture. Institution building in both the knowledge system and the marketing system could be spearheads. Here, the development paths described in Section 4 may serve as a source of inspiration.

6. Conclusions

The total greenhouse area in the Netherlands expanded from about 3,300 ha in 1950 to over 10,000 ha in 2000. The evolution was different for the various crop groups. In the period 1950-1965, the area expansion largely concerned vegetables. In the period 1965-1980 the area expansion largely concerned cut flowers. From 1980 onwards pot plants and tree nurseries were responsible for area expansion. On the other hand, the production of fruits (e.g. grapes) largely disappeared. Over the course of time, crop productivity and labour productivity improved tremendously. As a result, the cost price of tomatoes dropped from NLG 4.44 in 1954 to NLG 1.36 in 1982 (expressed in 1980 guilders).

The evolution patterns concerned are related to economic and social developments in Western Europe. In this development roughly four periods can be distinguished:

- 1945-1965: reconstruction after World War II;
- 1965-1980: unprecedented economic growth;
- 1980-1993: application of computer technology;
- 1993-2000: change to demand-driven economy.

The above-mentioned economic and social developments had far-reaching technical and institutional effects on greenhouse horticulture in the Netherlands. In the period 1945-1965, much attention was paid to soil fertility, plant protection and improving varieties. The switch from hotbeds to greenhouses considerably improved labour productivity. Extension and research acted as troubleshooter and problem-solver, respectively, for individual growers. The auctions played an important role in knowledge exchange.

In the period 1965-1980 much attention was paid to greenhouse heating, climate control and planting material. The switch to natural gas and the mechanization of climate control and harvesting/grading strongly improved labour productivity. Liberalization of the EU market gave a strong impulse to the export of vegetables and flowers. The period was characterized by strong cooperation between government and practice. The knowledge system played a leading role in that cooperation.

In the period 1980-1993 the personal computer enabled the application of many new technologies, such as the switch to substrate culture, trickle irrigation and CO_2 application. The knowledge system strongly supported the introduction of these new technologies by providing knowledge on climate control and development of management systems. The auctions also provided support through data-processing facilities. Moreover, they developed guidelines for environmentally responsible cultivation.

In the period 1993-2000, the knowledge system and the marketing system underwent radical changes. Both extension and research were privatized and started working on a contract basis. The horticultural sector established a research coordination bureau to translate growers' problems into research questions and to negotiate specific contracts with research stations and institutes. The market for horticultural products changed from supply-driven to demand-driven. The position of the vegetable auctions was no longer sovereign.

Growers' associations and trade marks were established to meet the needs of exporters and supermarkets. The auctions developed from a market place into a marketing partner for the buyers.

The position of horticulture in the Yangtze Delta on the time axis of Dutch greenhouse horticulture depends on the production system. Traditional horticulture and industrial horticulture in the Yangtze Delta show many technical similarities with Dutch greenhouse horticulture in 1960 and 1980, respectively. Greenhouse horticulture in the Netherlands is characterized by a remarkable coherence between knowledge, production and marketing. For Dutch horticulture, this seems to be an important success factor. Improving the coherence between knowledge, production and marketing seems to be an important condition to speed up the development of horticulture in the Yangtze Delta.

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