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NATIONAL INNOVATION SYSTEMS IN HORTICULTURE IN GERMANY AND THE NETHERLANDS

Klaus Menrad¹, Andreas Gabriel¹

a.gabriel@wz-straubing.de

¹ Chair of Marketing and Management of Biogenic Resources, Straubing Center of Science,
University of Applied Sciences Weihenstephan, Straubing, Germany

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Prof. Dr. Klaus Menrad

Science Centre Straubing
Schulgasse 16, 94315
Straubing, Germany
Email: k.menrad@wz-straubing.de

Andreas Gabriel

Science Centre Straubing
Schulgasse 16, 94315
Straubing, Germany
Email: a.gabriel@wz-straubing.de

1.1 Abstract

The paper compares the innovation systems of horticulture in Germany and the Netherlands which are both important producers of horticultural products in Europe. Based on the theoretical framework of national systems of innovation the characteristics of firms and important industries, the role of universities and education institutions as well as penetration of innovations related to horticulture are analysed for Germany and the Netherlands.

1.2 Introduction

Within the agricultural sector the production and marketing of horticultural products (mainly vegetables, fruits, cut flowers and pot plants, or ornamental shrubs and trees) plays a specific role since it is characterised by a high labour and capital intensity. On the demand side, there are only very few regulations intervening in the market systems of horticultural products resulting in high price fluctuations within the season and between years. The paper concentrates on the innovation system of horticultural products in Germany and the Netherlands which are both among the most important producers of horticultural products in the EU (21).

1.3 Theoretical framework

Innovation is a complex phenomenon, involving the production, diffusion and translation of scientific or technical knowledge into new or modified products and services as well as new production or processing techniques. Innovation is characterised by complicated feedback mechanisms and interactive relations involving science, technology, learning, production, policy and demand (8). In consequence, commercial companies almost never innovate in isolation but they interact with "organisations" of different types (e. g. suppliers, customers, research institutions, investment companies, government agencies) and their behaviour is shaped by "institutions" as well (8) which constitute constraints or incentives for innovation (e. g. laws, cultural or social rules, technical standards).

Due to their complex character, innovation activities represent an ideal area to use system theory approaches for the analysis of such processes on the level of a (national) economy "National Systems of Innovation" (NSI) is the most frequently used approach for understanding the complex relations of innovation processes. The NSI approach cannot be regarded as a formal theory, rather it provides a conceptual framework for ana-

lysing the specific factors influencing the innovative capabilities of companies (8, 9). The NSI approach rests on the four basic concepts of 'innovation', 'learning', 'system' and 'nation'. 'Innovation' refers to the activities of companies to develop, introduce and diffuse new products and production processes (15). These processes depend on 'learning' from a variety of activities undertaken within companies, on the co-ordination of this internal knowledge as well as its integration with knowledge acquired from external sources. Because innovation involves different forms of interactive learning, Lundvall suggests to address it within a 'systems approach' (12), which is common to all authors dealing with the NSI approach (8). The fourth basic concept of the NSI approach represents a "nation state" which is defined by the boundaries, not only in geographic terms (8, 12). Although the question whether geographic national boundaries still can be assumed for the national systems is discussed in scientific literature (e. g. 2, 18), Lundvall et al. 2002 come to the conclusion "that the national level remains important for certain innovation activities" (13), but demand-related aspects should be integrated in the NSI-approach (14) as consumer behaviour determines the activities of industrial companies to a high extent in a wide range of branches.

1.4 Results and discussion

The characteristics of firms and important industries, the role of universities and education institutions as well as penetration of innovations (example of micro-propagation techniques) in Germany and the Netherlands are analysed within this chapter. The information are collected using publicly available statistical information, scientific literature and reports as well as information of trade organisations. For analysing penetration of innovations additional interviews with experts have been carried out.

Firstly the structure, production and trade of the horticultural sector of Germany and the Netherlands are summarized in table 1. The relevance of the sector and the policies related to horticultural production differ between these countries: While in the Netherlands horticulture (and the total agro-industries) is regarded as one rather important branch in the national economy, this sector plays a minor role in the German economy. Due to the highly industrialized character of both countries only 2.6% (in Germany) or 3.1% (in the Netherlands) of all employees were working in the agricultural sector in 2001 (21). The 40,000 persons working in horticultural companies in Germany represent around 6% of the agricultural workforce compared to 61,000 persons working in horticulture in the Netherlands (around 30% of workforce in agriculture) (21).

Horticultural sector in Germany

At the beginning of the century, around 4% of all agricultural companies are specialized in horticultural production in Germany (21). In both fields of horticulture a significant decrease in the number of companies can be observed in recent 20 years resulting in around 13,000

Table 1: Structure of the horticultural sector in Germany and the Netherlands

Country	Germany		The Netherlands	
Factor	2000	2005	2000	2005
Number of companies				
Open field production	14,379	13,148	18,767	14,761
Greenhouse production	11,197	9,561	11,061	8,602
Cultivated area (hectares)				
Vegetables (field)	98,937	107,771	42,067	41,433
Vegetable (greenhouse)	1,342	1,392	4,200	4,345
Fruits	69,291	66,200	20,606	18,568
Ornamental shrubs/trees	24,690	22,983	12,641	14,546
Flowers (field)	4,373	5,116	23,000	22,000
Flowers (greenhouse)	2,683	2,524	5,683	5,339
Production value (million €)				
Vegetables	1,312	1,678	1,971	1,850
Fruits	707	783	326	335
Flowers	1,133	1,289	3,844	4,269
Ornamental shrubs/trees	600	595	548	550
Exports (million €)				
Fruits and vegetables	1,618	2,125	4,321	5,694
Flowers	261	362	4,019	4,500
Imports (million €)				
Fruits and vegetables	9,161	9,015	3,631	4,977
Flowers	2,012	2,005	1,054	1,138

Sources (5, 10, 11, 20, 30, 31)

companies active in open-field production and ca. 9,500 companies active in greenhouse horticulture in 2005 (table 1). Most of the companies are very small employing less than 10 persons and with greenhouse facilities of below 1 hectare. Due to the varying climate requirements the companies producing horticultural products are scattered among Germany impeding the development of specialised clusters.

The development of the cultivated area shows differing trends in the various production segments. While the area of open-field vegetable production doubles since 1990 to around 108,000 hectares in 2005 (table 1), there was a slight decrease in the area of fruit production to around 66,000 hectares in 2005 (table 1). Within floriculture the area used for ornamental shrubs or trees was reduced to around 22,000 hectares in 2005 while there was a slight increase in the acreage of open field flower production mainly for direct sales to end consumers. However, the area used for production of flowers in Germany is rather limited compared to the situation in the Netherlands (table 1).

This results in a production value of almost 1.3 billion € for flowers in 2005 in Germany (table 1) which showed an increasing trend in recent years. In analogy to the increase in acreage the production value of vegetables significantly grew to around 1.6 billion € in 2005, while the value of the produced fruits or ornamental

shrubs/trees stagnated around 750 to 800 million € or around 600 million € respectively (table 1).

From the demand side, the horticultural market in Germany represents the biggest market in Europe with a value of around 8.7 billion € for flowers and plants (16), and 8.4 billion € for fruits and vegetables (7). In contrast to the situation in the Netherlands the German market for horticultural products is characterised by a strong dominance of imported products in all areas of production (table 1). Mainly due to health and nutrition reasons consumption per capita is growing to around 82 kg/capita in fruits and 93 kg/capita in vegetables in 2004 (30, 31). While sales of cut flowers are decreasing to 39 €/capita in 2005, consumers' purchase of pot plants show an increasing trend to around 49 €/per capita in 2006 (16). While direct sales of horticultural producers to private and public customers are declining, specialised garden centres, DIY superstores, or food retail shops and discount markets are gaining relevance as distribution channels of horticultural products (16). This is in particular true for food horticultural products where seven food retail companies are responsible for more than three quarters of all sales in fruits and vegetables (7) thus putting pressure on the mostly small-scaled producers of such products.

Horticultural sector in the Netherlands

In recent 20 years horticulture has been a rather important and successful economic sector in the Netherlands. After the second world war Dutch producers developed a strong export positions in fresh vegetables but in the 1960s floriculture became the most important branch of horticulture in the Netherlands (27). Open field horticulture had a share of almost 8.5% in the added value in 2004, and almost 10% in employment within the Dutch agro-complex (10). The number of holdings with open field horticulture has declined by 70% since 1971 to around 14,700 companies (table 1), while the total area shrank by 6%. In this context the area used for fruit cultivation has almost halved, whereas the area used for tree cultivation has almost tripled.

In the Netherlands greenhouse horticulture (including mushroom production) had a 22% share in the added value in 2004, and a share of 17.5% in employment for the entire agro-complex (10). The area of greenhouse horticulture has grown from 7,370 hectares in 1971 to 10,540 hectares in 2005 entirely due to growth of ornamental plant cultivation while the area of greenhouse vegetable cultivation shrank from 5,275 hectares to 4,345 hectares during the period stated (table 1). Between 1971 and 2000, the area used for the cultivation of cut flowers grew from 715 hectares to 3,925 hectares, but has started to decline again since then. The area used for pot plants – amounting to 1,925 hectares in 2005 – is still growing. The number of greenhouse horticultural holdings almost halved between 1971 and 2005 to around 8,600 companies (table 1). The average area covered by greenhouses is 1.2 hectares per holding, and this is expected to increase to 2.5 hectares within ten years (10).

Characteristic for the horticultural production system in the Netherlands is a strong position of the co-operative growers organisations (27). The co-operatives had a common interest of selling the products of their producers at the highest price possible. For achieving this aim the well developed auction system for horticultural products played a significant role which is not established in Germany. Table 2 shows the development of the sales of important marketing organisations of horticultural products in the Netherlands and Germany with all of the major Dutch companies marketing mainly flowers worth more than 1.5 billion. The concentration of marketing facilities will further develop in the Netherlands since Bloemenveiling Aalsmeer and FloraHolland announced in November 2006 that they will merge their activities in 2008 (24).

Table 2: Revenues of important marketing organisations (million €)

Company	Country	1995	2000	2001	2005
Bloemenveiling Aalsmeer	NL	1,163.7	1,468.6	1,487.6	1,690
BVH, Naaldwijk*	NL	987.4	1,291.3	1,305.2	--
FloraHolland, Rjinsburg	NL	277.7	431.9	444.5	2,005
NBV/UGA (Landgard (since 2006)	GE	--	571.1	601.0	1,005

* BVH merged with Flora Holland in 2002 thus explaining the high growth in revenues in the latter company

Sources (1, 24)

Another important feature of the Dutch horticultural innovation system is the strong international orientation of the horticultural production system. This is documented in the fact that the Netherlands are the main exporting country of cut flowers and pot plants on a global level. Thereby the value of exported flowers exceeds the value of domestic production (table 1) since the Netherlands (and in particular Schiphol airport) offer excellent trading infrastructure for horticultural products. This is even more the case in the field of fruits and vegetables (table 1) since a lot of exotic or tropic fruits (e. g. bananas) are imported through the Dutch harbours and afterwards distributed in the EU. This high relevance of the Netherlands as the globally most important trading centre of horticultural products has its basic in the economic history of the country with the tradition in trading goods from its colonies and within Europe, an entrepreneurial attitude of the population, its central position within Western Europe, the tradition in horticultural production ("tulips in Amsterdam") due to shortage of land as well as a modern and efficient trade infrastructure. Furthermore a process of internationalisation has been going on among producers as well. An increasing number of Dutch horticultural companies has established subsidiaries in other European countries or overseas (27).

Changes in the innovation system in horticulture are additionally influenced by demand driven developments such as a growing purchasing power of retailers in par-

ticular in food products and changing consumer habits (27) in particular the "mass individualisation" of consumer behaviour also for horticultural products which means that demand of consumers is individualised and differentiated depending on the specific product, distribution channel, specific situation at the point of sale as well as the individual interests, preferences and needs of consumers. This means for producers that it is no longer sufficient to bring a product on the market with good quality meeting standard specifications but to satisfy strongly differentiated needs and preferences of various consumer groups. This will require a lot of flexibility from producers of horticultural products in order to adjust to continuously changing consumer preferences and market conditions.

Role of universities and education institutions

Knowledge generation in Germany

In Germany knowledge generation and diffusion in horticulture is organised in a de-centralized way and in various institutions. Due to the small-sized structure of most of the horticultural companies in Germany, R&D activities are often carried out in public institutions. In this context research activities at universities play an important role. This relates in particular to the Humboldt University, Berlin and University of Hannover, which offer own bachelor and master studies in horticulture. In addition, stand-alone bachelor studies in horticulture are offered at six universities of applied sciences (Berlin, Dresden, Erfurt, Osnabrueck, Weihenstephan, Wiesbaden). In 2004 around 30 professorships exist at German universities related to horticulture of which are the half at the University of Hannover. In addition there are around 36 professors active in the horticultural field at universities of applied sciences. It is planned that the number of professorships will significantly decrease in the coming five years (29).

While the number of students studying horticulture at German universities is decreasing in recent years there is an increasing number of students at universities of applied sciences which offer more practical elements in their curricula. This results in a total of around 1,100 students at universities and more than 1,700 students at universities of applied sciences in 2003 (29). In 2006 there have been around 110 graduates in horticulture at universities compared to 270 graduates at universities of applied sciences in Germany (29).

In addition to universities R&D activities related to horticulture are carried out in Federal research centres located in Berlin/Bruinswik (mainly in the field of plant protection) and in Quedlinburg (in particular in the field of plant breeding) (4). In addition there are several research institutions in this field which are run by single federal states with a total of around 160 scientists active in horticultural research (29).

There is no general overview available how many funds are used for horticultural R&D activities in Germany. Between 2001 and 2003 around 37 million € of external funds could be acquired by the different research insti-

tutions active in the horticultural field, with important parts being generated by universities (57%) and state run research institutions (23%) (29). Compared to a total of around 295 million € of external research funds which was acquired in the agricultural field in the same time period (29), this shows the limited relevance of horticultural R&D activities in Germany.

Knowledge generation in the Netherlands

In the Netherlands, the national government always contributed to a strongly developed horticultural sector by encouraging that authorities, private enterprises and research institutions co-operate and exchange knowledge (27) not least to support export of horticultural products. In recent years the national government changed its strategy in a sense that government authorities should leave more room in knowledge generation to the parties on the market. As a result, there was a significant concentration process going on the institutions related to education in agriculture and horticulture in the Netherlands. While in 1985 more than 200 institutions were involved in agricultural and horticultural education in the Netherlands, this figure was reduced to 20 institutions in 2003 (26). It has been decided to integrate all public institutes of agri- and horticultural research into a single organisation, i. e. the Knowledge Centre Wageningen, which includes the Agricultural University of Wageningen, various institutes of the Agricultural Research Department and some applied research stations. (27). In addition there are specific institutions which focus its research and innovation activities to the horticultural field like the Stichting Innovatie Glastuinbouw, the Innovation Center Wageningen, the agro-economic research institute LEI or a specific innovation network for Dutch agri- and horticulture.

In the Netherlands education for agriculture and horticulture is organised on four different levels, of which higher education is concentrated in six centres of higher education ("Hogeschool") and the Wageningen University and Research Centre. In 2003 a total of 8,400 students studied agriculture and horticulture at the centres of higher education in the Netherlands compared to around 4,000 students at Wageningen University (26). In parallel to the re-organisation process of the research infrastructure, the national Government of the Netherlands focused its research funds in the horticultural field on strengthening the area of basic research as well as developing partly public, partly private financed pre-competitive multidisciplinary research programmes, while research studies on company level will be entirely left to industry and trade. In addition, the public extension services for horticulture have been completely privatized in the Netherlands (27).

Penetration of innovations in the case of micro-propagation techniques

In the recent 25 years micro-propagation in horticulture has become an accepted commercial practice especially for ornamental plants. Micro-propagation is a technique of plant culture and plant propagation on agars in ster-

ile, closed vessels. Most common techniques for micro-propagation are axillary bud systems, adventitious shooting systems, somatic embryogenesis and meristem culture (22). Especially in the horticultural sector a fast, space-saving propagation of healthy plants is possible due to this method. Therefore large and uniform plant stocks can be produced and offered to customers to reasonable prices.

Micro-propagation techniques are mainly carried out in commercial and specialised laboratories as well as in labs of larger companies specialised in producing young plants. It is difficult to estimate the exact number of micro-propagating labs in the EU25 due to data gaps and often different fields of activities in commercial labs. However according to a survey conducted by the COST 822 programme in 1996 there are 505 laboratories situated in the EU, most of them in the Netherlands, Germany, United Kingdom, Belgium and Italy (17).

In 2002 the Netherlands showed the highest production (1,068 million €) and import values for young plant material for pot plants and cut flowers in Europe, followed by Germany with 908 million € which has a specific strength in the production on young rose plant material (6). In order to get an overview of micro-propagation of ornamental plants in Europe eleven horticultural companies active in this field – commercial labs and labs of young plant companies - as well as three experts of universities and associations were interviewed of which six companies are located in Germany and two in the Netherlands.

Evaluating the success of micro-propagation the interviewed companies clearly differentiate between the various plant cultures. Thus certain plants can only be propagated profitably by means of micro-propagation. Furthermore the huge demand for some ornamental plants like orchids can only be fulfilled by applying micro-propagation so that this technique is often regarded to be complementary to conventional young plant production methods. Further success factors of micro-propagation are the production of uniform and disease-free plants as well as continuous technical developments. Disadvantages of micro-propagation mainly concern smaller laboratories as they often have difficulties to produce the required large numbers of plants. Furthermore, they often can not keep up with the order situation and the special requirements of their customers.

The growth of micro-propagation activities in Germany can be illustrated with the help of data collected among the specialised laboratories organised in ADIVK e.V. After a strong growth in the number of laboratories in the mid 1980s, the total number of commercial micro-propagating laboratories remained stable around 30 in Germany since the 1990s (28). Concerning the size of the laboratories there are eight companies (27% of all labs) propagating more than 1 million plants per year with a total production of around 45 million plants which represents 92% of the total German production of around 49 million plants in 2004 (28). Analogue figures of the number of commercial micro-propagating labora-

tories are not available for the Netherlands. However, a strong increase in the number and size of such laboratories is reported between 1983 (28 labs) and 1990 (78 labs), followed by a decrease to 67 commercial labs in 1995 (19).

In Germany, the total production of micro-propagated plants increased from 5 million to nearly 20 million between 1985 and 1992. Followed by five years of stagnation, a strong growth in total production can be observed to more than 48 million plants in 2004 (28) which was entirely caused by a steep increase of the orchid *Phalaenopsis*. In 2004 German in vitro laboratories produced more than 31 million plants of this orchid. Only by applying micro-propagation techniques for production of uniform clonal cultivars replacing variable seedlings populations, it became possible to produce *Phalaenopsis* as a mass product (28). In addition, Germany has a long tradition in producing disease-free strawberries.

In analogy to the development in Germany commercial micro-propagation expanded in several Western European countries, including the Netherlands, in the mid 1980s followed by stagnation or even a decline in production in the 1990s (28). For the Netherlands the declining figures of micro-propagated plants are accompanied by increasing imports from countries with low wages (mainly Poland and India) (19). Statistics of the Netherlands also show an increase in micro-propagation of *Phalaenopsis* but not to the extent observed in Germany (19). Most of the micro-propagated horticultural products are marketed nationally or within the EU. There is only marginally export overseas according to estimations of the interviewed experts.

In the past the penetration of micro-propagation in horticulture was always dependant on trends on the demand side. One of its first drivers was the strong demand for micro-propagated cut flowers (e. g. Gerbera) in Europe in the 1980s. In recent years the general demand for cut flowers is decreasing, whereas the production of orchids gains central significance. The strong increase in market demand can be illustrated by the development of sales of the most common orchid *Phalaenopsis* at the flower auctions in the Netherlands (table 3) which represent around 14% of all sales in the segment of pot plants in the Netherlands in 2004 (25). In conclusion it can be stated that the penetration of micro-propagation techniques in horticulture highly relies on the market demand of consumers and thus can change significantly within a few years.

In recent years it can be observed that micro-propagation of many plants – others than orchids – is shifted to low-wages countries in Eastern Europe or Asia like India, Thailand, Indonesia, Taiwan or China. This is due to the high relevance of labour costs when running a commercial micro-propagation laboratory. The interviewed experts estimate the share of labour costs to range between 30% and 50% of the total costs of a commercial lab. Thus the labour-intensive production part of the business often is shifted to low-wages countries, but management, research and development

as well as marketing remains in Germany or the Netherlands. This trend also can be observed in the interviewed companies as well since two of them started new laboratories in Eastern Europe and employed therefore more than 100 new workers in the field of micro-propagation.

Table 3: Development of sales of *Phalaenopsis* in flower auction in the Netherlands

Year	Number of pots (mill.)	Average price (€/pot)	Turnover (million €)
2001	10.58	4.63	49
2002	12.325	5.23	64.439
2003	17.376	4.78	83.102
2004	23.8	4.61	109.746
2005	29.354	4.90	143.708

Source (25)

The qualification requirements of employees dealing with micro-propagation techniques differ from those employees working with conventional propagating methods. More biology or biotechnology-related know-how is needed in contrast to horticultural expertise in case of conventional propagation. According to the interviewed companies about 11 % of all employees are academics and qualified employees. There are also higher costs associated to micro-propagating horticultural plants due to the high personnel expenditures and the higher investment and running costs for micro-propagation laboratories compared to companies which use conventional propagating techniques. This is however compensated by the faster propagation and the production of large, uniform and healthy plant stocks, in particular in plants like orchids.

In conclusion it can be stated that both in Germany and in the Netherlands there is a significant penetration of micro-propagation among the relevant laboratories. The interviewed experts estimated that it is hardly possible to run a profitable horticultural young plant business without the use of micro-propagation. The future development in Germany mainly depends on the sales development of *Phalaenopsis* and other orchids, while in the Netherlands a broader range of micro-propagated plants are produced. Many European laboratories are already in competition with laboratories in countries with low-wage economy, e. g. Asian countries. In future in particular small-sized companies will have difficulties to stay in competition due to their limited production volumes both in Germany and in the Netherlands.

Conclusions

Comparing the German and Dutch innovation system for horticulture it can be shown that a centralized and clustered innovation and production system facilitates the realisation of economies of scales in producing and marketing horticultural products in the Netherlands. Knowledge generation and transfer is facilitated by a centralised structure of the institutions as well as a commercially-oriented organisation of the system giv-

ing high relevance and room to commercial actors in the Dutch system. In contrary the German knowledge system is characterised by a decentralised structure lacking co-ordination of activities of the different actors. Penetration of micro-propagation techniques is comparable among German and Dutch young plant producing laboratories and companies but the Dutch producers achieve a higher value added not least due to advantages in the trade and marketing infrastructure of horticultural products in this country.

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