

ANNEX C4

PITA Project: Policy Influences on Technology for Agriculture:
Chemicals, Biotechnology and Seeds

AgrEvo monograph

Annex C 4

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Introduction to the PITA Project

Technological innovation in the agrochemical, biotechnology and seeds industries and in associated public sector research establishments (PSREs) has the potential to deliver more socially and environmentally sustainable farming systems and to improve the quality of life of citizens in Europe. This is particularly true of farms on the most fertile land. However, although policies developed in different areas may all aim to improve the quality of life, in practice, in their influence on company and PSRE strategies, they frequently counteract one another and so attenuate the desired effect.

Market-related factors also influence decision making in industry and PSREs, the most important for this project being the policies of food processors and distributors and also public attitudes and opinion, which often set more demanding standards than those of national governments and the EU.

The PITA project (see Project Structure) is developing an integrated analysis of policies and market-related factors relevant to the agrochemical, biotechnology and seeds sectors. The core of the project is an investigation of the impact of these factors on the strategies and decision making of companies and PSREs and the downstream implications of these decisions on employment, international competitiveness and environmental benefits. The final outcome will be feedback of our conclusions to policy makers and company managers.

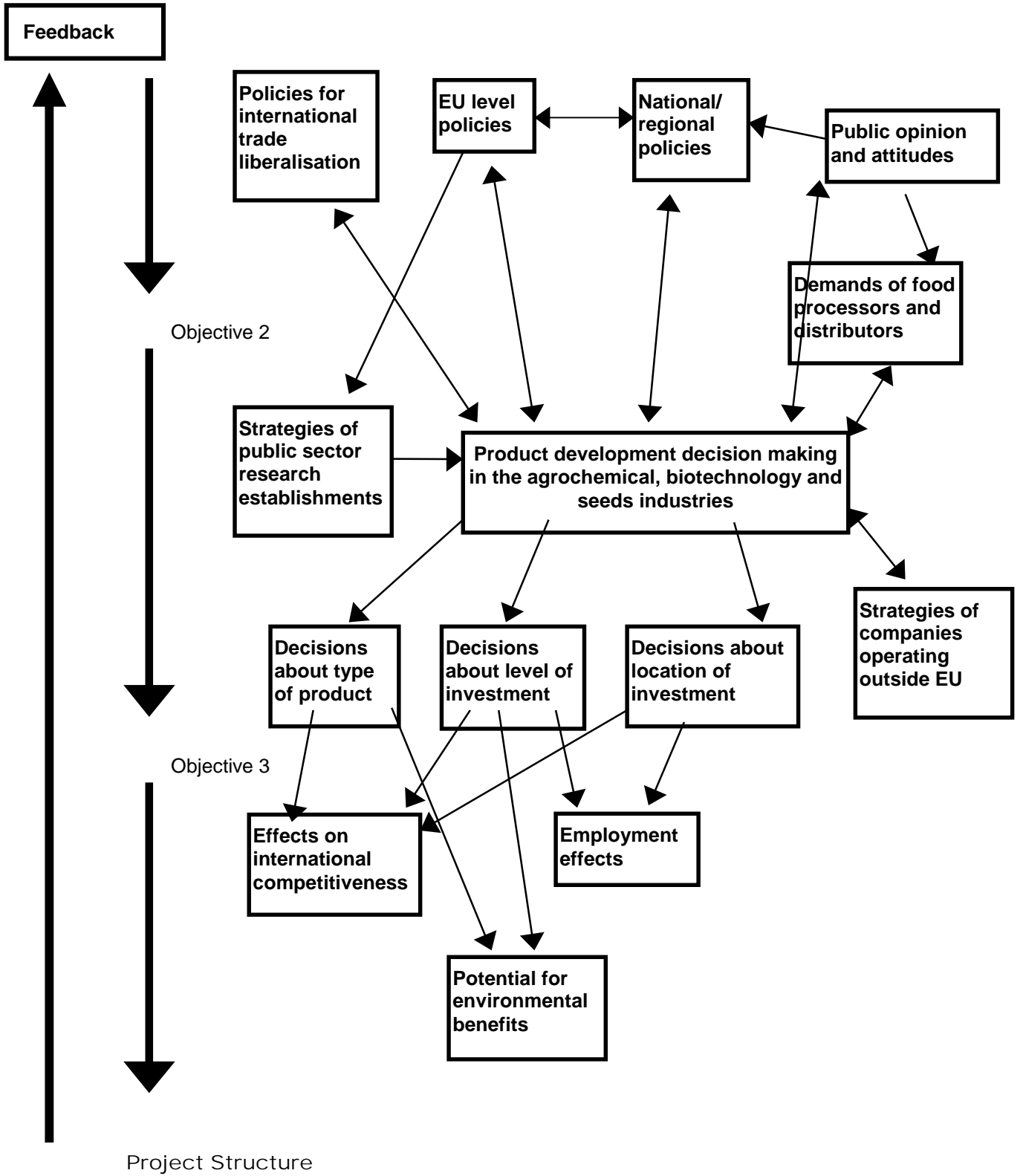
The range of policies and other influences studied includes:

- policies to stimulate innovation in the agrochemical, biotechnology and seeds industries;
- purchasing policies of food processors and distributors;
- policies for international trade liberalisation;
- policies for the regulation of industry and farming (for environmental protection and public health and safety, particularly for pesticides and biotechnology);
- agricultural and farming support policies, particularly for crop production;
- policies to promote environmental sustainability and wildlife biodiversity in arable farming areas;
- public opinion and attitudes.

The overall aim of the project is to contribute to the development of sustainable industrial and farming systems and an improved quality of life by encouraging the development and uptake of 'cleaner' technology for intensive agriculture. Its objectives are:

- to develop an integrated analysis of policies and market-related factors relevant to technological innovation in the agrochemical, biotechnology and seeds sectors, to study their interactions and to develop hypotheses about their impact on strategic decision making in industry and PSREs.
- to study the influence of policies and market-related factors on innovation strategies in the agrochemical, biotechnology and seeds industries and PSREs, and their impact on decisions about product development, levels of investment and location of investment.
- to study the outcomes of the industry decisions investigated under objective 2, in their effects on employment, on international competitiveness and on their potential to deliver environmental benefits.

Objective 1

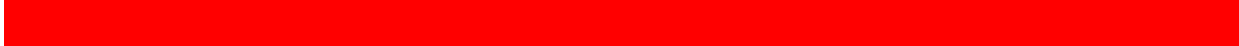


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1. Introduction

This monograph reports on the innovation strategy of AgrEvo, a Frankfurt (Germany) based crop protection company.

This report has been written on the basis of two kinds of sources: (1) material published by the company itself (annual reports, news releases, web site) and material published by others (in research reports, newspapers, trade journals); (2) interviews with several AgrEvo managers in Germany and The Netherlands. We would like to thank these managers for their collaboration and for the information supplied.

This report is structured as follows. Section 2 gives general background information on AgrEvo, particularly key facts and figures, and highlights in the recent history of the company. Section 3 describes the innovation strategies of the company. Although AgrEvo is primarily an agrochemical company, it is in the middle of a shift from providing crop protection products to providing integrated crop production solutions to farmers. In this shift, biotechnology plays a major role. In section 4 we discuss the AgrEvo organisation of decision making on innovation. Section 5 presents the impact of public policies and market developments as they are felt by AgrEvo. The next section presents the internal discourse on environmental and sustainability issues. Finally, in section 7, some conclusions are drawn on innovation strategies and decision making, on impact of public policies on innovation, and on environment issues in relation to innovation.

In 1999, AgrEvo's majority shareholder Hoechst merged with the French pharmaceutical and chemical company Rhône-Poulenc. As part of this merger, AgrEvo and Rhône-Poulenc Agro have been merged to form Aventis CropScience. This monograph presents an analysis of AgrEvo before the merger.

2. AgrEvo

2.1 Brief description of the company

Hoechst Schering AgrEvo GmbH (to be named AgrEvo hereafter) develops and manufactures agrochemicals for crop protection as well as for non-agricultural applications. AgrEvo's main products are herbicides, insecticides and fungicides, for all major agricultural crops as well as fruit and vegetables. AgrEvo also sells seeds, both for vegetable and field crops. For maize, canola, sugar beet and soybeans, AgrEvo has developed (or is developing) genetically modified varieties. Besides its products for the farming sector, AgrEvo also sells agrochemical products for non-agricultural uses, particularly to control insects in human environments.

AgrEvo is a German company, with its formal headquarters in Berlin, but most of its management located in Frankfurt am Main. AgrEvo is a joint venture of the German chemical and pharmaceutical companies Hoechst and Schering. In 1994 these companies combined their agrochemical business to establish AgrEvo, in order to benefit from economies of scale in marketing and R&D.

One of the main elements of AgrEvo's current strategy is the transition from crop protection to crop production. AgrEvo no longer wants to sell only crop protection products, but seeks to provide productivity enhancing solutions to the farmer. Biotechnology is a major element in this strategic reorientation, as the focus in crop protection is shifting from the chemical molecule to the plant itself. Expanding in the seed business is part of the implementation of this strategy.

2.2 Key facts and figures

World-wide, AgrEvo is the fourth largest producer of crop protection products, after Novartis, Monsanto and Zeneca. In the European market, AgrEvo is the second largest supplier of agrochemicals, with a market share of approximately 12 percent (1998 Annual Report). In 1998, AgrEvo had a turnover of 2.1 billion Euro (Table 1), investments in R&D being about 12 percent of sales, or approximately 250 million Euro.

Table 1. Financial figures (million Euro)

	1994	1995	1996	1997	1998
Net sales	1,658.5	1,679.0	1,819.5	2,034.5	2,121.5
Operating profit	17.0	84.0	97.0	157.0	176.5
Cash flow	n.a.	94.0	217.0	253.5	145.5
R&D costs	209.0	194.0	217.0	255.5	247.5
Investments in fixed assets	49.0	53.5	71.5	118.5	65.5
Employment	n.a.	7,459	7,427	8,550	8,658

Source: AgrEvo Annual Reports 1997 and 1998.

Herbicides are AgrEvo's main product, representing 42 percent of turnover (Table 2). AgrEvo has a share of 8 percent in the world herbicide market (1997 Annual Report). Forty percent of AgrEvo's herbicide production is sold in Europe. For sugar-beet and cereal herbicides the company is market leader in Europe. AgrEvo is particularly strong in grass-herbicides for cereals, with products like Puma/Excel and Illoxan (Table 3). For sugar beet, the main herbicide is Betanal.

Table 2. Sales by main product groups (million Euro and % of total)

Products	1997	1998
Herbicides	855.0 (42%)	880.5 (42%)
Insecticides	472.0 (23%)	454.0 (21%)
Fungicides	314.5 (16%)	341.0 (16%)
Environmental Health	218.5 (11%)	194.5 (9%)
Seeds/Crop Improvement	66.0 (3%)	119.0 (6%)
Others	108.5 (5%)	132.5 (6%)
Total	2121.5 (100%)	2134.5 (100%)

Source: AgrEvo Annual Report 1998

A very important herbicide for AgrEvo's biotechnology ambitions is Liberty. Liberty is a new formulation of the non-selective herbicide glufosinate, that AgrEvo and Hoechst have been selling under various brand names (e.g., Basta, Ignite, Finale and Challenge) since 1984. Glufosinate has particularly been used on fruit and vegetable crops, but Liberty can now be used large scale on transgenic field crops.

In insecticides, AgrEvo has a market share of about 8 percent (1997 Annual Report). Decis is the main product, applied on various crops. Europe is the main sales area, accounting for 67% of insecticide sales.

Table 3. Main products in 1997 (ranked on turnover)

Brand name	Type of product	Active ingredient	Main crops
1. Puma, Excel	Herbicide	Fenoxaprop-Ethyl	Cereals
2. Betanal	Herbicide	PMP/DMP/Etho	Sugar beet
3. Basta	Herbicide	Glufosinate	Non-selective
4. Illoxan	Herbicide	Diclofop-methyl	Cereals
5. Liberty	Herbicide	Glufosinate	Various herbicide-tolerant crops
6. Decis	Insecticide	Deltamethrine	Corn, Soybean, Cotton, Vegetables
7. Thiodan	Insecticide	Endosulfan	Soybean, Cotton
8. Dropp	Defoliant	Thidiazuron	Cotton
9. Sportak	Fungicide	Prochloraz	Cereals
10. Previcur/Tattoo	Fungicide	Propamocarb	Potatoes, Vegetables

Source: compiled on the basis of information from AgrEvo 1997 Annual Report and the AgrEvo website, visited 23 November 1998.

Fungicides sales are more evenly distributed over the various regions of the world, with Asia Pacific (34%) the most important sales region (1997 Annual Report). AgrEvo's fungicide business essentially comprises two portfolios of products. The first group of products, including the best selling product Sportak, is mainly for application to cereals. Europe is the main market for these products. The second group contains products for application to horticulture, vines and potatoes. Previcur/Tattoo, used for control of – among others – late blight in potatoes, belongs to this group of products.

Environmental Health products include household insecticides, non-agricultural professional pesticides, home & garden products, and products for turf and amenity grass fields (like golf courses).

Seeds/Crop Improvement is the biotechnology and seeds business of AgrEvo. This product group was newly formed in 1997, after the acquisition of PGS and the shift of Nunhems Seeds from parent company Hoechst to AgrEvo and was originally called Biotech & Seeds. Although this business activity still accounts for only a small percentage of AgrEvo's turnover, it is considered the main strategic growth area (see Section 3 on innovation strategy). The main crops in this group are canola (oilseed rape), maize, soybean and vegetables.

Europe continues to be most important region for AgrEvo; 37 percent of turnover is realised in this part of the world (Table 4). Germany is the most important country for AgrEvo. Gradually other regions are becoming more important, with most of the growth in North and South America.

In Europe, AgrEvo has affiliated companies in each country. Some of the companies are only sales organisations, others include research and manufacturing activities. R&D and production of agrochemicals is done by AgrEvo itself, while most of the seeds and biotechnology activities are located at subsidiaries. R&D on agrochemicals is located in Frankfurt am Main, Germany. Production takes place in Germany, UK, Netherlands, France and Spain. Production and distribution of generic pesticides is done by the subsidiary Stefes Agro, in Germany.

Table 4. Sales by region (percentage of total)

Region	1996	1997	1998
Europe	42	37	37

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North America	17	20	19
Asia Pacific	20	19	18
Latin America	12	13	15
International	7	7	6
Others	1	4	6

Source: AgrEvo Annual Reports 1997 and 1998.

2.3 Mergers, acquisitions, investments and divestments

The start

In January 1994 the two German chemical and pharmaceutical companies Hoechst and Schering officially merged their agrochemical business in a new company called AgrEvo (the name is an acronym for agro-evolution). The legal name of the joint venture is Hoechst Schering AgrEvo GmbH. The Hoechst Group holds a 60 percent stake (43 percent for Hoechst AG and 17 percent for the French company Roussel-Uclaf). Schering AG holds a 40 percent stake. The product portfolios of the two founding companies were complementary. Hoechst was strong in cereal herbicides and insecticides. Schering's competitive edge was in cereal fungicides and sugar beet herbicides. Roussel-Uclaf transferred its activities for public hygiene and household pesticides to AgrEvo and this became the core of the Environmental Health business unit.

The decision to start this joint venture was forced by increasing competition in the crop protection business, allowing only a few big companies to survive. Less favourable market conditions encouraged agrochemical companies to invest more in developing new products, and only large companies can afford such high R&D spending. At its start, AgrEvo expected to be spending 150 million Euro a year on R&D. The new company started with a total turnover of 1.6 billion Euro, 42% in Europe and 19% in North America.

Acquisitions, investments and divestments in agrochemicals

In 1995, AgrEvo bought the South-Korean agrochemical firm Misung, and took a majority share (75%) in Stefes Agro, a European producer and distributor of generic pesticides. In 1997, Bayer acquired a 49.9% stake in Misung International which formulated and distributed both AgrEvo and Bayer products. In 2000 AgrEvo divested its share in Misung which became wholly owned by Bayer.

Based on positive expectations of selling LibertyLink corn and LibertyLink canola, AgrEvo is increasing its production capacity, by investing nearly 50% of its 1997 investments in fixed assets, Liberty manufacturing plants in Germany and the USA.

In 1998, AgrEvo sold its fertiliser company Aglukon Spezialdünger (Düsseldorf, Germany), as part of its strategy to focus on plant protection, pest control and biotech-based plant production and also divested its US branded consumer Home and Garden business to The Scotts Company.

In 1999, AgrEvo established a joint venture (Bilag Industries) with Mitsu Industries Limited (MIL) of India, part of the Bilakhia Group of Companies, to produce both synthetic pyrethroid insecticides for the agricultural market and other pyrethroids for the environmental health market. AgrEvo holds 51% of the shares in the joint venture which has the objective to combine the production expertise of MIL in the field of pyrethroids and their intermediates with the world-wide marketing and distribution network of AgrEvo. The joint venture will further strengthen AgrEvo's insecticide business.

Expansion in biotechnology and seeds

In 1985, Hoechst took a minority share in, and started joined research with, KWS, the main German seed company for field crops (particular sugar beet). In 1986, Hoechst initiated research in what the company called 'green biotechnology', i.e. plant biotechnology. Hoechst

acquired the Dutch vegetable seed company Nunhems Seeds. Schering, together with the Senate of Berlin, established the Institute for Biogenetic Research (IGF), in Berlin, Germany.

In 1996, AgrEvo bought the Belgian plant biotechnology firm Plant Genetic Systems (PGS) 436 million Euro. In 1995 PGS turnover was 4 million Euro, but the company was not making any profit. PGS was one of the largest and most advanced plant biotechnology firms in Europe, established in 1982, with 140 employees in 1996. PGS evolved out of a group of researchers from the University of Gent, with early links to Monsanto, and was very successful in genetic engineering of crop plants like sugar beet, oilseed rape (canola), tomato, tobacco, potato and lucerne. In collaboration with Hoechst/AgrEvo it developed herbicide resistant plants for the herbicide glufosinate, produced by Hoechst/AgrEvo. It also developed a biotechnological technique to generate male sterility in the crop plants like corn and rape which makes the development of hybrid varieties less laborious. PGS had also started to expand in the seed business, combining expertise on biotechnology and plant breeding and has a strong patent base for transformation techniques and for male sterility techniques.

PGS had established its own canola seed business in Canada and started a joint venture with the Indian seed company Proagro. In 1997, AgrEvo established an international cotton seed joint venture with Cotton Seed International (CSI) of Wee Waa, Australia. The new company, called AgrEvo Cotton Seeds International (ACSI), is based in Memphis, Tennessee, USA. AgrEvo owns 51 per cent of ACSI, and CSI owns 49%. ACSI develops cotton varieties for the USA and other markets. With ACSI, AgrEvo seeks to become a major player in the US and international cotton seed markets.

In 1998, AgrEvo announced that it will acquire the American seed company Cargill Hybrid Seeds North America for 650 million US dollar (Cargill turnover amounted to approx 106 million US dollar). Through Cargill, AgrEvo would obtain direct access to the North-American corn market and to genetically modified corn varieties. However, due to a legal dispute between Cargill and Pioneer Hi-Bred International about infringement of patents, the acquisition was cancelled.

Also in 1998, AgrEvo acquired the rice breeding program and associated assets of the Brazilian seed company Granja 4 Irmaos. Granja was the leading producer and supplier of rice seeds in Brazil, while its affiliated company Josapar, was the country's largest rice grain retailer. Granja was developing hybrid rice in collaboration with the French national research institute CIRAD. Granja 4 Irmaos S.A., based in Pelotas, Brazil, cultivated annually a rice area of 7,000 hectares, being the main Josapar supplier.

In 1999, AgrEvo acquired the Proagro Group of companies which comprised Proagro Seed Company Ltd., Proagro-PGS India Ltd., Hybrid Rice International, and MISR Hytech. The Proagro Group was the second largest seed company in India, ranked no. 1 in hybrid corn, millet and forage sorghum and no. 2 in sunflower and grain sorghum. The Proagro Group was also developing hybrid rice, cotton, oilseed rape and vegetables for India and other markets in Asia, the Middle East and North Africa.

This same year, AgrEvo acquired the Brazilian seed companies Sementes Ribeiral Ltda. (Ribeiral) and Sementes Fartura Ltda. (Fartura), as well as the corn research company Mitla Pesquisa Agricola Ltda. (Mitla). Ribeiral and Fartura were formed in 1973 and 1976 respectively. Mitla was formed in 1993 as the joint corn research company of Ribeiral and Fartura. The combined turnover of the three companies in 1998 was approximately 9 million USD. Together the companies accounted for approximately 8% of the Brazilian hybrid corn seed market. The companies also produced soybean and sorghum seed for the Brazilian market. Together, they had 132 employees. Mitla was a foundation corn seed company engaged in the breeding and development of proprietary corn parent lines.

AgrEvo also expanded in vegetable crops. In 1997, Nunhems Seeds was shifted from the parent company Hoechst to AgrEvo and AgrEvo acquired the American seed company Sunseed Corporation (Sunseeds), California. Sunseeds produced hybrid vegetable seeds and had 300 employees world-wide. It had a fully owned subsidiary in India and joint ventures in China and Chile. It occupied a leading market position in the field of carrots and

onions in the USA. It also sold seeds for fresh and processing tomato, melon, watermelon and cucumber. Nunhems and Sunseeds became the two business units of the holding company Nunza BV. In 1998, Nunza acquired Leen de Mos, from Advanta VanderHave, the Dutch vegetable seed company, strengthening its market position in seed for cucumber and lettuce. Leen de Mos employed 50 people and had an establishment in Almeria, Spain. In India, Sunseeds India was integrated with Proagro-PGS to create a single joint venture – Nunhems-Proagro. With the 1999 acquisition of Proagro by AgrEvo, the company was fully integrated in Nunza. Also in 1999, Nunza acquired Rio Colorado Seeds, California, USA which specialised in hybrid onion seeds. The company had 35 employees. In 1998, Nunza was number four in the world-wide vegetable seeds market, with approximately 900 employees, of which 275 are located at Nunhems in the Netherlands.

In 1999, AgrEvo acquired a majority share (95%) in the German dedicated plant biotechnology company PlantTec Biotechnologie.

AgrEvo become Aventis CropScience

In December 1999, Hoechst AG and Rhône-Poulenc S.A. merged into Aventis and Rhône-Poulenc Agro and AgrEvo formed Aventis CropScience.

2.4 Research locations

AgrEvo has research facilities in several parts of the world but most of the research is located in Europe at Frankfurt am Main. Here most of the research on crop protection takes place, particularly on herbicides, insecticides and process development (i.e. the development of synthesis routes for crop protection products) along with some research on plant biotechnology employing about 350 people. Research on agrochemicals, particularly on formulations also takes place in USA, UK, Japan, France, and Belgium.

AgrEvo's main research location for plant biotechnology continues to be at PGS in Gent, working on both fundamental and applied plant biotechnology and also conventional plant breeding. PGS also has breeding programmes for oilseed rape/canola in Canada. With the acquisitions listed above, AgrEvo/PGS has substantially expanded its crop breeding activities in cotton (USA), rice (India, Brazil), maize (India, Brazil), and several other field crops.

Applied research on vegetable crops is located at Nunhems (Haelen, Netherlands), Sunseeds (California, USA) and Proagro (India). Research on biotechnology and seed technology (for improving seeds through coating, priming, pilling) for vegetable crops is concentrated in the Netherlands.

3. Innovation strategy

3.1 Introduction

AgrEvo's innovation strategy can be summarised by the following statement by dr. G. Prante, AgrEvo's CEO at a Press Conference in November 1997: "We have taken the strategic decision to develop from a plant protection enterprise to a company offering farmers products for enhancing the productivity of plant production through innovations in chemistry, biotechnology and plant breeding".¹

Most of the information in the 1997 Annual Report was still structured according to AgrEvo's five product groups – herbicides, insecticides, fungicides, environmental health and biotech/seeds. In the 1998 Annual Report, however, the information is presented on a crop basis: cereals, corn, oilseed rape/canola, soybean, sugar-beet, rice, vegetables and cotton.

¹ Retrieved from the Internet: www.agrevo.com/visions/vision11.htm, on 7 May 1999.

Synergy between biotech/seeds and agrochemicals is expected from functional genomics research which can be used for research on biotechnology traits in crop improvement and for identifying leads in crop protection products. Synergy benefits come from the knowledge of how chemicals and genes interact in the cell. Functional genomics provides information on the functions of genes. Genomic information on the one hand is the key to produce distinct chemicals, and on the other hand chemicals can influence the working of genes (switch on/switch off). Basic knowledge on the functioning of genes, and thus of the effect of certain chemicals on this functioning, can be applied to plants, animals and human beings alike.

Genomics is the foundation of the life science concept applied by many large companies in the pharmaceutical, agrochemical and biotechnology industries which use their knowledge for the development of products for human and animal drugs, plant protection products and seeds.²

3.2 Agrochemicals

The strategic focus on crop production does not mean that agrochemicals are no longer a core activity of AgrEvo. Biotechnology and plant breeding are complementary to AgrEvo's expertise in developing, manufacturing and marketing agrochemicals. Looking at the turnover figures in Section 1.2 above, seeds and crop improvement account for only a small percentage for total sales. Also the figures on research expenditures show the continued importance of agrochemicals: in 1997 nearly 80% of R&D spending was focussed on chemicals and 20% on biotech. New methods such as combinatorial chemistry have greatly increased screening capacities, and have major repercussions on the role of molecular synthesis. However, AgrEvo expects that the balance of R&D spending will increasingly tilt towards biotechnology. In future, the distinction between biotechnology and non-biotechnology research will fade (1997 Annual Report).

AgrEvo has nine new chemical compounds under development and will launch them in the period 1999 – 2003. The main emphasis is on herbicides for rice, wheat and other cereals, and on fungicides for cereals, fruit and vines (Table 5).

Table 5. New product releases

Product	Crop	Launch date	Expected Market Size (million US\$)
Safener	Rice, Maize	2000	3.5
Herbicide	Cereals	2002	1.9
Fungicide	Cereals, Fruit	2002	1.8
Herbicide	Maize	2002	2.2
Herbicide	Cereals	2002	1.9
Herbicide	Rice	2003	1.3

Source: Agrow, 1997, no 282, p. 3

In 1999 AgrEvo was developing two new iodosulfuron-based herbicides for the European cereal market. Both products will be launched around 2001/2002 for use world-wide. AgrEvo has obtained French approval for its new herbicide safener, mefenpyr-diethyl which was launched in Germany in 1997 and has since been approved in Australia, Austria and the UK for use on wheat. AgrEvo is awaiting French approval for use in cereal seed treatments. The company hopes to obtain approvals in the UK, Germany and Belgium by late 1999 or 2000. AgrEvo is also awaiting approval for two fluquinconazole-based foliar fungicides, which it

² While Aventis still adheres to the life science concept, some of its competitors, notably Novartis and AstraZeneca, have partly retreated from this route by divesting their agribusiness (agrochemicals, plant biotechnology, seed) activities.

hopes to introduce in the French cereal market in the autumn of 1999. AgrEvo's cereal seed treatment, Kinto TS, received French approval in May 1999 and was due to be launched to seed processors in the summer of that year. AgrEvo is awaiting approval for sale to French farmers under the trade name, Semants, in the autumn of 1999. The company hopes to sell enough product to treat 70,000 tonnes of seed in the first year and up to 100,000 tonnes in later years (*Agrow*, 11 June 1999, no 330, p. 26).

3.3 Biotechnology and seeds

From the early 1980s, when the first results of biotechnology research become known and a bright future for this new key technology was forecasted, Hoechst has been active in biotechnology research. As a pharmaceutical company, it heavily invested in biotechnology R&D, particularly in the USA³. As a major producer of agrochemicals, research on plant biotechnology was only a small step to make. Hoechst had both in-house research and research contracts with small biotechnology companies. Research on herbicide-tolerance (glufosinate-tolerance) was contracted to PGS.

The importance of seeds for the biotechnology business was already acknowledged in the 1980s. In 1985, Hoechst took a minority share in and started research collaboration with KWS (for field crops). In 1986 Hoechst acquired Nunhems Seeds, a Dutch vegetables seed company.

In 1995 AgrEvo took the strategic decision to become a serious player in the global plant biotechnology industry. Several developments led to this decision. First, Hoechst had built up biotechnology expertise and saw good commercial prospects. Second, the market prospects for agrochemicals, particularly in Europe and North America, were not very positive. Third, major competitors, particularly Monsanto, were all heavily investing in biotechnology and seeds. Fourth, the herbicide-resistance technology developed by PGS for AgrEvo's broad-spectrum herbicide glufosinate was ready for commercialisation. Thus, AgrEvo decided to expand in biotechnology and in seeds as it acknowledged that for commercialisation of biotechnology access to seeds is indispensable.

The 1996 acquisition of PGS was a major step in implementing the new strategy. PGS brought to AgrEvo extensive knowledge of plant biotechnology as well as plant breeding. PGS was one of the most successful dedicated biotechnology firms. Another important quality of PGS was its very good intellectual property position. Through its active patenting policy, PGS not only had good protection for its own technology, it also had a good position for getting access to proprietary technology of other companies. By cross-licensing patents and genes, PGS had low-cost, broad access to other biotechnologies. This resulting 'freedom to operate' is considered very important for success in the plant biotechnology industry. PGS biotechnology research had focused on three main application areas: weed control, insect control and hybrid breeding (Bijman, 1994). The resulting products are named *LibertyLink*, *StarLink* and *SeedLink* respectively.

LibertyLink refers to crops with genetically engineered glufosinate tolerance. The first LibertyLink canola varieties were introduced by PGS in Canada in 1995. In 1997, LibertyLink maize varieties were introduced in the USA. For maize, AgrEvo/PGS does not produce its own seeds, but has alliances with all major maize seed companies in the North America. In Europe, AgrEvo/PGS has several LibertyLink crop varieties approved under Directive 90/220 – rape, chicory and maize – while others are pending approval (CEC, 2000). Importation of grain derived from LibertyLink maize was approved by the European Union in 1998.

StarLink refers to genetically engineered crops which produce their own insecticide (*Bacillus thuringiensis* crystal protein). StarLink maize has been grown in the US since 1999. For these varieties, AgrEvo/PGS is the technology provider, while the germplasm comes from the seed companies AgrEvo/PGS has alliances with.

³ In 1981 Hoechst signed a contract for research collaboration on health-related biotechnology with Massachusetts General Hospital, Boston, USA.

SeedLink refers to hybrid seeds obtained by genetical engineering. For the commercialisation of its hybridisation technology, PGS had decided to start its own breeding programme for canola. For this crop, no hybrids existed, while research has shown that substantial yield enhancement would be possible by planting hybrid varieties instead of conventional varieties. Since 1997 *SeedLink* canola hybrids have been grown by farmers in Canada and the United States. AgrEvo/PGS is now a major supplier of canola seeds in North America. AgrEvo/PGS considers Europe as another important market for hybrid oilseed rape varieties (1998 Annual Report). Hybrid oilseed rape varieties will also be introduced in India and Australia. The *SeedLink* technology will also be used for other crops, notably vegetables.

Besides its breeding activities in oilseed rape/canola, AgrEvo is also investing in the acquisition of breeding programmes for other field crops. It has started its own cotton seed company in Memphis (USA) in collaboration with the Australian company Cotton Seed International. For rice, it has acquired a Brazilian seed company and it has obtained full ownership of the Indian seed company Proagro. The Proagro acquisition has also been important, for maize as has as the acquisition of several other Brazilian seed companies.

While AgrEvo/PGS focuses on field crops, research on vegetable crops is done by Nunza. Although Nunza is fully owned by AgrEvo, it has a relatively independent position. This independence was agreed when Nunhems was acquired by Hoechst in 1986, and has been maintained ever since (not least by being a profitable company). Applied biotechnology research as well as research on conventional breeding and reproduction techniques is done at Nunhems headquarters, in Haelen, Netherlands. In 1998 a new research laboratory for biotechnology, seed technology and phytopathology was opened at this location. Nunhems and PGS work closely together in research on plant breeding and reproduction and on applied plant biotechnology. PGS expertise on plant biotechnology is now also applied in the vegetable breeding programmes of Nunhems. The main difference, however, between PGS and Nunhems is that PGS develops transgenic crop varieties, but Nunhems does not and will not do so. In vegetable breeding extensive use is made of marker technologies and other techniques of molecular breeding, but no transgenic varieties are being commercialised. The main reason is that in Europe – Nunhems' main market – consumers do not accept genetically modified vegetables.

So far, most plant biotechnology research of AgrEvo/PGS has focussed on agronomic traits. Still, AgrEvo is expanding its research budget spent on output or quality traits. This focus on output traits is shown by the acquisition of the majority ownership (95%) of PlantTec Biotechnologie GmbH (AgrEvo media release, 16 September 1999) a small German biotechnology company, which specializes in improving carbohydrate metabolism in plants. The objective of research at PlantTec is to achieve higher yielding plants, to enhance food and animal feed quality, and to develop extractable carbohydrates such as starch with specially tailored characteristics. For instance, it is working on improving the starch content of potatoes. PlantTec was set up in 1996 by members of the staff of the former Berlin Institute für Genbiologische Forschung, established in 1986 by the Senate of Berlin and Schering.

3.4 Research alliances

AgrEvo has research alliances for both its agrochemical and biotechnology activities. On the chemistry side most expertise and techniques needed for screening and synthesising large numbers of chemical compounds (techniques like high-throughput screening and combinatorial chemistry) are available in-house, but on the biotechnology side there are more research alliances, for example, on genomics. With the developments in functional genomics, research on biotechnology and agrochemicals becomes increasingly integrated as most alliances with genomics companies aim at finding interesting genes for both crop protection and crop production.

In 1997 AgrEvo signed a non-exclusive licensing agreement with the US company Kimeragen (Newton, Pennsylvania), covering Kimeragen's proprietary "Chimeraplasty" technology in plants. The technology is designed to enable targeted gene repair, replacement and modification. AgrEvo and PGS employ Kimeragen's technology to identify plant gene

ANNEX C4

functions in crops of interest as well as for targeting specific gene modifications (*Agrow*, 1997, no 292, p. 3).

In 1998 AgrEvo entered into a 5 year strategic biotechnology research alliance with the Australian research institute CSIRO, to focus on the protection of crops against insect pests and diseases and the improvement of cotton fibre quality. According to Jan Leemans, AgrEvo's director of seeds and biotechnology, the collaboration will enhance AgrEvo's position in the evolving crop production industry (*Agrow*, 26 June 1998, no 307, p. 3).

In July 1998 AgrEvo entered into a research collaboration with the US genomics company Gene Logic, of Gaithersburg, MD, USA, aimed at the discovery of genes for the development of new crop protection and crop improvement products. The collaboration will run for three years, with a possible extension for a further five years. AgrEvo will pay research and database access fees, which could amount to more than 45 million US dollars over the full term of the agreement. AgrEvo considers that innovative crop protection and crop improvement products will increasingly be based on gene leads coming from genomics technologies such as those developed by Gene Logic. (*Agrow*, 10 July 1998, no 308, p. 6).

Also in 1998, AgrEvo acquired a basic patent on transgenic sugar beet from Limagrain, to strengthen its position as a technology provider in that crop. The company also entered into several license agreements: e.g. on basic enabling technology for wheat and corn transformation from Japan Tobacco; and on metabolic engineering technology from the Max Planck Institute (Germany). The latter technology aims to redirect plant metabolic pathways to increase yield and plant performance.

In 1999, AgrEvo has signed an agreement with Molecular Simulations Incorporation (MSI), a subsidiary of Pharmacoepia, San Diego, USA, to accelerate its discovery of new agrochemical compounds. MSI provides its molecular modelling software for use in finding active ingredient leads, lead optimisation and combinatorial chemistry (*Agrow*, 1999, no 321, p. 4).

In Germany, AgrEvo is collaborating in a consortium of several seed and biotechnology companies together with public research institutes like the Max Planck Institut für Züchtungsforschung in a large plant genomics research programme. This GABI programme (Genome Analyse im Biologischen systemplantze) is a public-private partnership with one part targeting fundamental research and fully funded by the German government, and another part jointly funded by the government and participating companies and targeted at more applied research projects.

Also in 1999, AgrEvo/PGS signed a research agreement with the Centre for Plant Breeding and Reproduction Research (CPRO), of Wageningen, Netherlands, for the functional analysis of genes in important plant species, Arabidopsis, Brassica oilseeds, wheat and rice. Understanding the role of specific genes in the development and metabolism of these plants should allow AgrEvo and CPRO to develop and improve their respective crops through genetic engineering and advanced breeding strategies.

3.5 Life sciences

AgrEvo strongly believes in the synergistic effects of combining various life science activities, at least in research. Already under Hoechst there was an interaction between pharmaceuticals research and agrochemicals research. Several agrochemicals were originally synthesised as pharmaceuticals. For instance, one of Hoechst main products in the 1980s, Illoxan, a lipid synthesis inhibitor, came out of pharmaceutical research on fat metabolism. Now with biotechnology and genomics, the synergy is even stronger. In biotechnology one can use genomics for screening genes and finding their mode of action, and their function. In synthesising and screening chemicals one can also use genomics to discover the mode of action of distinct chemicals. Moreover, chemicals can be used to influence genes, to switch them on or to switch them off. The co-operation at the cellular level between chemicals and genes is a very interesting story with a lot of synergistic effects, according to AgrEvo managers.

Although there is good reason to combine research on pharmaceuticals and agrochemicals, AgrEvo managers acknowledge the potential drawbacks of this combination from a marketing point of view. Agrochemicals are sold to different clients from pharmaceuticals and pharmaceutical markets show different profit margins from agricultural (i.e. agrochemicals and seeds) markets.

3.6 Conclusion

The acquisition of PGS in 1996 and the subsequent acquisitions of a great number of seed companies, both for field crops and vegetables, have been major steps in the innovation strategy of AgrEvo. The core of this strategy is a shift from being purely a producer of crop protection products on the basis of agrochemicals to becoming a provider of crop production solutions based on the combination of seeds (with optimal pest resistance) and chemicals. Biotechnology is an important tool to develop the best combination of internal (varietal) and external crop protection.

AgrEvo is convinced that sufficient agricultural production can only be achieved in future with the aid of plant biotechnology. Even before the take-over, PGS had decided that, for commercialisation of its plant biotechnology research, access to the best crop varieties is indispensable. A plant biotechnology company can either contract with seed companies or acquire seed companies itself. AgrEvo is following both routes. In the words of an AgrEvo manager: "You have to have an envelope to send your post". AgrEvo is acquiring seed companies in several parts of the world to be able to compete successfully with other seed companies, to recoup heavy investments in biotechnology by incorporating its proprietary technology in as many varieties as possible, and to spread the risks that are inherent in the seed industry. Besides investing in the acquisition of elite germplasm, AgrEvo is also investing further in biotechnology research, particularly focused on genomics both in-house and contracted out. Discovery of valuable genes for both crop protection and crop production is the main goal of this research.

4. Innovation decision making

4.1 General decision making

AgrEvo has structured its operations in several ways. It has divided the world into four regions (Table 4): Europe, North America (Canada, USA and Mexico), Asia-Pacific, Latin America and International (consisting of Turkey, CIS countries, parts of Central Asia and the Middle East, and Africa). Within each region, the company is structured by crop rather than by country. The European activities are covered by seven crop business teams: cereals, industrial crops (oilseed rape and maize), sugar beet, potatoes, vegetables, vines and top fruits/citrus. Each team is responsible for turnover and profitability in its own area. The role of the country manager is still in place, but its position is less senior than that of the crop business manager.

In the board of directors, each member has responsibility for a region, for a group of products and for certain functional activities in the company (Table 6). For R&D, AgrEvo has two directors: Jürgen Asshauer for agrochemicals and Jan Leemans for Biotechnology. Jan Leemans was director of PGS when AgrEvo acquired this company. While R&D on agrochemicals is still four times as large as biotechnology, giving Leemans a seat on the board of directors can be seen as an indication of the importance of plant biotechnology for AgrEvo.

Table 6. 1998 Members of the board of directors and their responsibilities

Name	Region	Indication Area	Function
Gerhard Prante	---	---	Chairman of the board and CEO
Jürgen Asshauer	Europe	Insecticides	R&D Agrochemicals
Peter Henkel	International	Fungicides	Personnel & Administration
Jan Leemans	---	Seeds and crop improvement	R&D Biotechnology
Ian McManus	North America	Environmental health	Production
Hans-Jörg Timmer	Asia Pacific, Latin America	Herbicides	Marketing

Source: AgrEvo, 1998 Annual Report.

AgrEvo has a centralised decision-making structure: R&D and manufacturing decisions are all taken by the headquarters in Germany. This is partly explained by the German culture of business organisation, which is more centralised than in the Anglo-Saxon countries. Also the type of activity favours central direction, as there are substantial economies of scale and many intellectual property issues in the development and manufacturing of agrochemicals.

However, many decisions have to be taken on the basis of local factors. Differences in regulatory requirements, agronomic practices, soil and climate, culture of farming and incidence of pests all require a local or regional approach. Thus, most marketing decisions are taken on a decentralised basis. In the 1980s AgrEvo has strengthened the local decision making power, in line with the general trend of decentralisation in business organisation. The main reason for giving local affiliates more discretionary power is strengthening the marketing effort, thus shortening the time to market of new products.

4.2 Project management

Within AgrEvo, new product development is a combined effort of technology teams and business teams (1997 Annual Report). The technology teams are located at the R&D headquarters in Frankfurt or Gent, while the business teams are organised on a region + crop basis. The technology teams have full responsibility for shepherding a portfolio of molecules or biotech traits from the laboratory to the market. The corresponding regional business team works with the technology team from the very beginning of the development of any molecule or trait to match the final end-product to the customer's needs. Business teams were introduced to "focus the organisation on crop platforms" (1997 Annual Report, p. 8). They were first introduced in Europe in 1996 and a year later in the other regions.

An important platform for innovation decisions is the Development Marketing Committee which discusses and decides on new product development projects. This committee is chaired by Dr. Asshauer, chief technology officer and member of the board of directors. The committee combines knowledge of R&D, marketing, production, finance, and regulatory affairs. Regulatory requirements are very important in the innovation process, and are considered early in the process. Regulation has become more important over the years, shown by the fact that the only person with a veto in the Development Marketing Committee is the person from Regulatory Affairs.

In 1989 the Agriculture Division at Hoechst started the concept of project management. This means that each project for the development of a new technology or a new product follows defined procedures for decision-making, planning and evaluation of a project. AgrEvo has a special group of people, headed by dr. Jürgen Henrich, dealing with all the procedural aspects of managing a project: project execution plans, decision making procedures, monitoring and evaluation procedures, etc. This group delivers the management system to

people carrying out a project. It is also a moderator of the whole project management process, and it brings consistency, reliability, and transparency into the innovation decision making processes. Having all projects follow the same management structure helps the members of the board of directors to compare projects and make unbiased decisions. It is also a knowledge management tool, as it helps to turn implicit (or tacit) knowledge into explicit knowledge.

AgrEvo is convinced that its organisational structure shortens the product development process period (the time between the discovery and the launch of a product onto the market) from the traditional 12 years to between 8 and 10 (*Agrow, 1997, no 274, p. 3*).

4.3 Decision making on innovation

The introduction of biotechnology, particularly of genetically modified varieties, has strengthened central decision making. Because the main agricultural crops are traded internationally, decisions about the introduction of transgenic crop varieties have to take into account the regulatory affairs concerning biotechnology in other countries. Local decisions on crops can have global repercussions. Even when a product is not exported, the influence of pressure groups campaigning against biotechnology encourages AgrEvo to take a global perspective in deciding whether to market a transgenic crop. Thus, the world-wide debate on the merits of biotechnology and the activism of globally operating NGO's like Greenpeace has even shifted marketing decisions from the local and regional affiliates back to headquarters in Frankfurt. This re-centralisation of decision making has been a major cultural change within the company, and it is expected to take some time before it will be fully accepted and incorporated.

AgrEvo acknowledges that it has underestimated the effects of globalisation and the need to incorporate these effects in decision making on biotechnology projects. Both the interdependencies across the globe through international trade in agricultural products and the global actions of NGOs have made AgrEvo aware that it can no longer rely on regional approval systems. Nowadays, it is essential to have approval in various parts of the world but even that is not sufficient as the general public also has to accept the new products. AgrEvo is now aware that it has to consider the interests of a much wider group of stakeholders, not only its traditional customers, but the whole food chain, and in the end even the consumer.

AgrEvo managers emphasise that decision making in agrochemicals is routine, because the company has long experience and because legal requirements are clear and similar all over the world. For new agrochemicals the company knows which tests to do and what information to provide to regulators although the legal requirements are becoming more stringent, the decision making process is more or less straightforward. On the biotechnology side, the learning curve is much steeper, because there is a great deal of uncertainty: different requirements in different countries, low transparency in the (political) decision making process, adding new requirements all the time, approval at one level of regulation and prohibition at another, etc. This has made decision making on biotechnology innovation extremely difficult.

4.4 Conclusion

Although innovation can only be successful if customer demands are fulfilled, AgrEvo can still be characterised as a technology-driven company. All of AgrEvo's public statements and publications emphasise the importance of R&D and technological innovation in remaining competitive and in reaching the goals of enhancing agricultural productivity as well as protecting nature. The importance of technological development is also shown by the fact that two of the six members of the board of directors have R&D as their main responsibility (Table 6). The conclusion that AgrEvo is more technology driven than market driven can also be drawn from the fact that it has been divesting its agrochemical retail organisation, preferring to sell its products to local retailers who supply farmers. This implies that direct commercial contact between the final customers – the farmers – and the AgrEvo organisation is limited to a small number of extension specialists.

Although plant biotechnology and crop breeding have become the strategic growth areas for AgrEvo, the incorporation of biotechnology activities into a traditional agrochemical company is a slow process. Not only are there still two board managers for agrochemical and biotechnology research, integration is also difficult at the level of the business units. Those engaged in traditional agrochemical research and production sometimes look jealously at the amount of investment available for biotechnology research. Moreover, the integration of a small, research based biotechnology company into a large, traditional agrochemical producer is not an easy process.

5. Impact of public policies and market developments

5.1 Introduction

An agrochemical company like AgrEvo is faced with restrictions and opportunities caused by government policies at national and international levels. R&D activities (in agrochemicals and biotechnology) are encouraged by governmental technology policies (providing subsidies and other incentives) but are also restricted by regulations on the safety for humans, animals and the environment. On the market side, AgrEvo is indirectly affected by the restrictions and opportunities that clients face. As AgrEvo's main clients are farmers, changes in agricultural policies which influence farmer decisions may affect AgrEvo's innovation strategies.

Besides the influence of government policies on AgrEvo's activities and strategies, several market-related factors also influence its innovation strategy. These are developments further down the agrifood production and distribution chain that influence farmers' choices and thus influence AgrEvo's market prospects. An example is the consumer concern for pesticide use in food cultivation. As consumers want food products with fewer pesticide residues, farmers will choose cultivation methods that require fewer (or other) pesticides. Such a development may induce an agrochemical company to develop plant protection products that leave fewer residues and that fit in integrated crop management systems.

In this chapter we present the impact that government policies and market-related factors will have on AgrEvo's strategy, particularly its innovation strategy. Three areas of government policies are distinguished: science, technology and innovation policies; environmental protection, public health and biodiversity policies; and farm support and international trade policies.

5.2 Science, technology and innovation (STI) policies

Policies on the protection of intellectual property rights are very important for AgrEvo. On the one hand the company is developing its own techniques and finding its own genes, and wants to protect these findings. The patent portfolio of PGS has proven to be of strategic importance for the development and commercialisation of transgenic crops. On the other hand the company is faced with uncertainties in patent protection and unwillingness of some patent holders to license their proprietary technology.

Uncertainties around intellectual property protection lead to difficulties in getting licences, to using other ways for protection of proprietary technology, and to a risk of high litigation costs. Only the largest companies can afford these legal fights over unclear patents. Thus, freedom to operate in the commercialisation of plant biotechnology requires extensive negotiations with owners of proprietary techniques and genes. The strength of a company in these negotiations depends very much its own patent portfolio and/or on its market share in the seed business.

Concerning biotechnology innovation, 'freedom to operate' is one of the first issues that AgrEvo discusses in its decision making process. If the intellectual property rights of the necessary techniques and genes are unclear or if it is almost certain that no licenses can be obtained, the project is cancelled. Uncertainty about protection of intellectual property rights

is also a reason for AgrEvo to follow a cautious strategy in investing in Asian countries like China and India.

AgrEvo is content with the changes in R&D policies on biotechnology of the German government that took place in the mid-1990s. While in the 1980s and early 1990s there was reluctant governmental support for biotechnology, this changed around 1995. Partly as a result of intensive lobbying by the large agrochemical and pharmaceutical companies, the ministries of Economic Affairs and of Research have set up several support programmes for the biotechnology industry. Under one such programme, the 1997 BioRegio programme, the government offered substantial subsidies to the regions for promoting biotechnology research. Regions were competing with ideas and projects, and stimulated each other in offering favourable conditions for biotechnology research.

In 1999, AgrEvo Canada has been awarded a 310,000 US dollar grant by the Saskatchewan government to develop improved wheat hybrids suited to the region (*Agrow*, 28 May 28 1999, no 329, p. 22).

5.3 Environment, public health and biodiversity policies

As a producer of agrochemicals, AgrEvo is directly affected by environmental policies and public health policies. These policies set the limits within which a chemical crop protection product can be developed and used. In pesticide regulation, the requirements are gradually becoming more stringent. These incremental changes do not pose serious difficulties for the company. For instance, as water issues have become more important in recent years, impact on water quality has become more critical in the product development process. However, one AgrEvo manager remarked that the requirements for water quality are rather generic. It would be better if they were product specific so that each product is assessed on its full environmental impact.

The agrochemical business is a mature industry, which means that companies have a lot of experience in investigating the environmental impact of new active ingredients. Often companies like AgrEvo are doing more investigations than legally required, so when new requirements are added, they have the answers ready. Testing and investigating critical points is a steady and evolutionary concept, applied for 30 to 40 years now.

Market opportunities are being narrowed by regulation, particularly the availability of (new) pesticides for small crops like vegetables. As regulatory requirements become more strict and additional information has to be supplied, AgrEvo will focus more on large crops where the money spent on research, development, testing and registration can be recouped. There is a certain volume of product that has to be sold before the company makes any profit and that volume has steadily over the last fifteen years. There will be fewer and fewer pesticides available for small crops.

On the issue of GMOs however, there is much more uncertainty, leading to difficulties in decision making on innovation and leading to high costs of product development. In 1989, AgrEvo had its first field trials with genetically modified plants in France and in the USA and Canada. Particularly among farmers, the main clients, AgrEvo did not see a different attitude between Europe and North America. But the regulation that was decided upon for these field trials and for further introduction of GMOs turned out to be very different on both sides of the Atlantic. In America there is the so-called deregulation since 1993: once a product is considered safe, further activities with this product do not have to be approved, and labelling and segregation is not needed. AgrEvo favours this type of regulation because it regulates the product and not a technology. In Europe, on the other hand, a GMO remains a GMO even when it is approved. This leads to the demand for labelling and for repetitive approvals for products derived from the GMO crop. These differences in the type of regulation between Europe and North America have made it very difficult for AgrEvo to decide what products to develop.

The European regulation on labelling, thresholds and segregation, particularly the lengthy uncertainty about what the rules would be, have also influenced AgrEvo's innovation activities targeted at the North American market. The absence of clear thresholds for what is

considered a GMO or a non-GMO product makes it particularly difficult: as zero cross pollination is not possible, a threshold has to be established, and communicated to the general public so that no false statements are made on whether a product is GMO-free.

On the revision of Directive 90/220, AgrEvo has taken a supportive position. It sees this revision, with its basis in the precautionary principle, as an important step in regaining public confidence in plant biotechnology. It acknowledges the need for labelling, for a more transparent decision making structure, and for more stringent risk assessment guidelines to be applied by all member states. As the current *de facto* moratorium on the introduction of GMOs is hampering AgrEvo's biotechnology innovation strategy, the company favours the implementation of the new requirements even before the Directive officially goes into force (expected in 2002). Other provisions in the revised Directive are time-limited approvals and the need for monitoring effects of GM crops. AgrEvo is not against these requirements, although the time of the approval has to be long enough to be able to recoup the investment. The issue of monitoring is not a problem, as it generates information the company can use to improve its products.

The requirements of the revised Directive 90/220 may be more difficult for seed companies, as they have to make the decision whether to use their elite germplasm for GM or non-GM varieties. AgrEvo expects that these companies will be more reluctant to develop GM varieties, as the time-limited approval makes it difficult for them to continue breeding with the GM variety. Thus, the revised Directive 90/220 will have clear repercussions on the development and the speed of introduction of GM varieties. This may even be a reason for AgrEvo to accelerate its acquisition of seed companies. Having direct control over seed companies may be the only way to get its technology into the top varieties.

Very restrictive regulation and cumbersome decision making in Europe may lead to a shift in R&D from Europe to North America. In North America it takes 9 months to get a registration. In Europe it takes two or three years, and even then, individual countries may illegally ban the product. This is why a technology that was primarily developed in Europe, plant biotechnology, is now shifting to America.

Decision making in Europe, or rather the absence of it, also influences AgrEvo's activities in North America. In March 1999 AgrEvo decided to delay the US introduction of its glufosinate-tolerant LibertyLink soybeans for another year because of continuing uncertainty about approvals in overseas markets, particularly in Europe and Japan. AgrEvo has all the necessary North American approvals in place, but is reluctant to introduce the soybeans because of potential difficulties in international trade (*Agrow, 26 March 1999, no. 325, p. 25*).

AgrEvo plans to introduce glufosinate-tolerant LibertyLink rice simultaneously in the US and overseas only when all the necessary international approvals are in place. The USDA approved two LibertyLink rice lines in February 1999 allowing AgrEvo to carry out extensive variety evaluation and seed multiplication ahead of a planned launch in 2001. AgrEvo plans to establish two rice breeding stations in California and Mississippi with a view to developing LibertyLink varieties adapted to California and the southern US rice growing regions. Field evaluations are also carried out in Latin America and trials are planned in Italy in 1999 (*Agrow, 28 May 1999, no 329, p. 22*).

5.4 Farm support and international trade policies

Shifts in set-aside policies or international trade policies, as part of the reform of the Common Agricultural Policy (CAP), can lead to changes in the cultivated area per crop. For instance, more set-aside may lead to less cereal production and thus diminish sales of wheat pesticides. If this is a structural shift, lower sales will lead eventually to lower investment in developing new cereal pesticides.

Policies that lead to a liberalisation of international trade in agricultural products increase the chance that GMO products introduced in one part of the globe end up in markets in others.. Thus, the interdependencies among biotechnology regulation in various countries in the world have become stronger. AgrEvo has learned to deal with these interdependencies by centralising decision making on the introduction of GMO crops.

5.5 Developments in the food chain and consumer markets

AgrEvo favours freedom of choice for the consumer and thus accepts labelling of genetically modified food products. Labelling of transgenic seeds is already normal business procedure for AgrEvo products. Labelling of food products is the responsibility of the producer of the (final) food product, not of the supplier of seeds and agrochemicals.

Labelling can only be done if GMO and non-GMO products can be separated. Modern identifying technology is now available to find out whether a food product comes from a GMO-plant or not. However, testing and labelling is only useful if clear and workable thresholds exist. With clear regulations on thresholds and labelling, GMO and non-GMO products can be segregated and the consumer can be informed in a meaningful way.

AgrEvo was not used to public pressure from NGOs working all around the world. Dealing with NGOs, particularly environmental NGOs, was basically a national or regional issue. With the increasing globalisation, AgrEvo found itself faced with protests from NGOs that, with the help of information and communication technology, exchange information and co-ordinate their actions world-wide. Now, AgrEvo is aware that it has a much larger group of stakeholders, all along the agrifood chain, including the final consumer.

For the introduction of genetically modified forage maize seed (LibertyLink maize) in the Netherlands, AgrEvo consults with the main farmers' organisation, with the Product Board for Feed, and with the dairy industry. Such consultation with firms downstream in the food chain is a new phenomenon and was induced by the difficult public acceptance of biotechnology. AgrEvo wants to find out about the opinions and demands of the companies downstream in the agrifood chain. For the same reason, the feed and food industry wants to stay informed about the characteristics and the eventual commercialisation of transgenic crops.

6. Company discourse on environmental issues

The extent to which a company like AgrEvo can and will develop environmentally friendly products depends on the combination of market opportunities and technological capabilities. However, market opportunities as perceived by the company are interpretations of reality. The products that are eventually developed depend on how managers at several places in the company perceive the opportunities, see strategic options and translate these into particular information and actions.

Within a large company like AgrEvo, several opinions and assessments may circulate about current and future environmental issues and about the commercial opportunities they present. This section presents the various discourses within the company on environmental issues. However, it has been difficult to characterize the environmental discourse within AgrEvo. More interviews with managers in different parts of the company would have been needed. The information contains diverse observations on environmental issues, some found in official AgrEvo publications, others from the AgrEvo managers interviewed.

In a 1996 brochure, AgrEvo stated its vision on sustainable development and environmental issues which can be summarised in the slogan "a healthy environment and food for all people". AgrEvo wants to help increase agricultural productivity, while at same time protecting nature: "All over the world we support high-yield, sustainable agriculture based on intelligent solutions in crop protection and environmental health, as well as green gene technology. At the same time preserving the environment and natural resources to maximum effect. We help to optimise the usage of existing farmland and to protect Nature against further destruction". AgrEvo believes that agricultural production and biodiversity preservation can only be in harmony if the production is high-yielding. High-yield agriculture requires less space, thus leaving part of the farmland to nature. In these natural landscapes, various species will develop undisturbed.

Biotechnology is a major tool in achieving these goals: "We at AgrEvo are committed to green gene technology, with which we aim to make crop breeding even more efficient and environmentally friendly." Weed control is optimised by making "crops tolerant to

environmentally sound and easily degradable herbicides". According to AgrEvo, "green technology is the key technology for sustainable agriculture".

In achieving sustainable agriculture, Integrated Crop Management (ICM) plays a major role. In a 1999 brochure, AgrEvo has defined ICM as follows: "ICM is a whole farm policy aiming to provide the basis for efficient and profitable production, which is economically viable and environmentally responsible". The Integrated Crop Management approach sees economic and ecological considerations as being of equal value and relies on a combination of conventional cultivation techniques and modern technology. ICM recognises that fertilisers and crop protection inputs are necessary to achieve modern farming in balance with nature. The part of ICM dealing with control of damaging weeds, pests and diseases is called Integrated Pest Management (IPM). AgrEvo's definition of Integrated Pest Management is as follows: "IPM is the optimal combination of cultural, plant-breeding, biological, and chemical measures to produce a cost-effective, ecologically sound, and socially acceptable form of crop protection for the control of weeds, diseases, insects, and other pests, which the farmer can use as a precise tool in the situation in question".

Although AgrEvo agrees with pesticide registration becoming more stringent, the company would like to see more flexibility in the approval procedure. Under the current procedure, a new product is assessed on all the latest criteria individually. There is no overall environmental performance assessment. The result of this procedure is that particular products are rejected that may have a better overall environmental performance but are not good enough on one specific criterion. The result of this strict procedure is that glufosinate-herbicide for over-the-top application in maize is not approved in the Netherlands, although it would be a substitute for more polluting products and so it cannot be used in a targeted combination with LibertyLink maize.

In the Netherlands the trade organisation of the agrochemical industry, Nefyto, is developing an environmental yardstick that can be used to assess the environmental impact of each crop protection product. This yardstick is broader than the one developed by the Centre for Agriculture and Environment (CLM), because it also includes economic and convenience criteria. AgrEvo headquarters is reluctant to introduce and use such a yardstick, as it can easily be used to blacklist specific pesticides. If a company has only products with very low environmental impact, it would be desirable to use such a list. However, companies always have (older) products that do score so well on the yardstick. Moreover, such an assessment system should be region specific, because it has to take into account the variety in regional agro-ecological conditions.

7. Conclusion

Hoechst Schering AgrEvo GmbH is one of the largest agrochemical companies in the world. Its main activities are the development, manufacturing and marketing of crop protection products like herbicides, insecticides and fungicides. Although it sells these products worldwide, Europe is still the main sales region, accounting for 37 percent of turnover in 1998.

In 1995 AgrEvo made the strategic decision to become a global player in the plant biotechnology industry. It acquired Plant Genetic Systems (PGS), one of the leading dedicated plant biotechnology companies in 1996. In the following years, it has acquired several seed companies in various parts of the world. For commercialisation of plant biotechnology research, access to elite germplasm is needed. This can be obtained by signing strategic alliances with seed companies or by setting up own breeding programmes. AgrEvo/PGS has followed several routes: it has set up its in-house breeding programme for canola/oilseed rape, it has acquired several seed companies and it has strategic alliances with other seed companies. Which strategy is chosen depends on the specific crop and the specific market situation.

AgrEvo is investing both in field crops and vegetable crops. Field crops are most interesting from a commercial point of view, because of the scale of the cultivation area. Vegetables are interesting because of the high margins, the greater technological and marketing flexibility in

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developing new varieties, and the closer interactions with companies further down the agrifood production chain.

The first generation of transgenic crop varieties marketed by AgrEvo focus on herbicide-tolerance (*LibertyLink*), insect-resistance (*StarLink*) and hybrid seeds (*SeedLink*). These are the proprietary technology developed by PGS. AgrEvo is also doing research on quality characteristics, but it may take some time before marketable products are available. Currently the main market for transgenic seeds with AgrEvo technology is North America. The most important crops are canola, maize, soybean and cotton. For other field crops, the company is also developing transgenic varieties, alone or in collaboration with another seed company.

Regulation of plant protection products in Europe is rather straightforward. Although registration requirements are becoming increasingly stringent, this does not pose serious problems for AgrEvo. As a result, innovation decision making on new plant protection products follows standardized procedures. Regulation of GMO crops, however, is rather difficult in Europe, unlike North America, AgrEvo has been faced with many delays and uncertainties, making innovation decision making a difficult and unpredictable process. The European regulatory situation has even had an impact on AgrEvo's activities in North America, as products like maize are shipped from there to Europe.

Other public policies also have some impact on AgrEvo innovation strategy. STI policies are important because they help public research institutes to enhance their biotechnology expertise. Policies for the protection of intellectual property rights are important as they provide protection for research results. Unclear or too broad legal protection makes it difficult to obtain 'freedom to operate' and thus may block certain innovation projects. Farm support policies have an impact on AgrEvo strategy because reform of the CAP leads to changes in the cultivation area of particular crops, and because lower prices lead to lower demand for the newest plant protection products. International trade policies are relevant because more liberalised markets may lead to more trade flows, which means that introduction of GMO crops in one region has to take into account regulation and public attitude in other regions.

Discourses on environmental issues focus on the traditional goals of improving the environmental impact of pesticides and developing crop varieties with enhanced pest resistance. AgrEvo believes that its herbicide-tolerance technology (*LibertyLink*) results in a better environmental performance than other herbicides used in the some crop.

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