ANNEX D1

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

Small and Medium Enterprises (SMEs) in Agrochemicals, Seeds and Plant Biotechnology: Overview

Annex D 1

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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.

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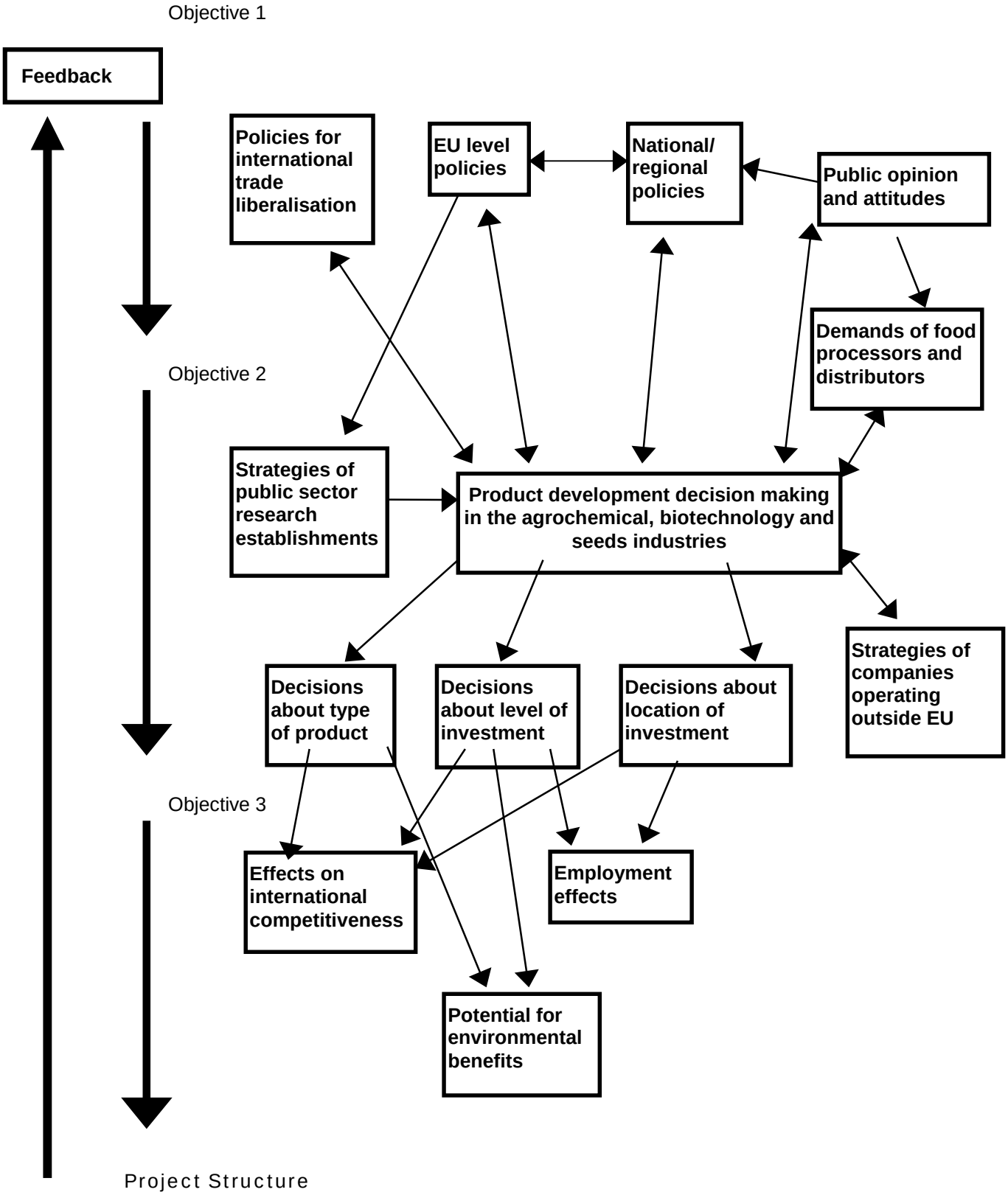
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1. An overview of European SMEs situation in agrochemicals, seeds and biotechnology

Seeds and agrochemical industries are undergoing crucial transformations and changes in their activities. The main forces that stimulate these changes are the following:

- The globalisation of the agro–food sector. Ever since the 1990s, the globalisation process of agro–food industry has become more important, a fact which has brought about the interdependence of agro–food systems of different parts of the world. Multinational groups organise the greater part of food production and distribution worldwide and consequently this process is losing its traditional local character. Seeds and agrochemical industries have also followed this trend, so as to somehow satisfy the needs of agro–food companies and final consumers, although their operational lines were different. In the case of agrochemical products, the dominant companies have traditionally been big ones because of economies of scale in the production, research and registration of new products, and because of their connections with chemical and pharmaceutical sectors (Bijman, 1999a) As regards seeds, most of the companies were small and family owned, but large scale food production and profitability of some varieties has stimulated the growing of companies, especially in the case of major crops (Bijman, 1999b)
- The use of biotechnology in the production process. This usage has tightened the links between these sectors and has stimulated faster mergers and purchases of companies throughout the whole production and distribution act so as to take full advantage of biotechnology possibilities. However, this use brings some uncertainty, since these possibilities are still not fully known, they provoke important social concerns, and the regulations are still being developed.
- Increasing pressure from public opinion and from policies aiming to reduce the environmental impact of agriculture, improve the quality and safety of food. Although the result of this pressure, in terms of new products or processes, are still uncertain, companies are facing the new demands and stricter laws which will have a decisive influence on their strategies for the next few years.

These factors, and others, determine the operation and the role of SMEs. Next, we will describe the main features of the SMEs in each of the chosen sectors.

Agrochemicals

The market for agrochemicals had consolidated in the mid 1980s. The market was concentrated in the hands of multinational companies that would face the expiry of patents of many of their main products in the following years.

Biotechnology offered an opportunity to develop varieties with new qualities (e.g. agrochemical, pest, and disease–resistance) and so brought seeds and agrochemical businesses nearer. Because of that, these big companies started to buy seed companies in order to control the necessary amount of scientific knowledge and market share and to obtain products with a full protection period.

Today the European market for agrochemicals is dominated by a few multinational companies that control the R&D activities, the discovery of new active ingredients and the production. On the other hand, the processes of formulation and generic production, bottling and distribution are carried out by SMEs. There exist numerous SMEs whose main activity is only distribution. Currently, there are just a few independent agrochemical–producing companies in Europe, most of which are multinational corporations' subsidiaries.

This situation holds in all the studied countries. In Denmark, with the exception of Cheminova which has more than 1000 employees and can not be characterized as a SME, most of the national companies do not produce agrochemicals. On the contrary, their main activity is the

import and sale of the products or the manufacture of chemical fertilisers. In The Netherlands, from the 19 companies that account for 95% of domestic sales, only Aseptafabriek BV is an independent SME, but this company only registers, tests and sells pesticides developed by other companies. Other two companies, ProAgro and Luxan, could be considered as SMEs, but they are fully owned by larger companies, although they have got high independence to define their own strategy. In Spain 90% of pesticide production is in the hands of multinational companies. The main activity of the SMEs is to formulate new products based on active substances whose patent has expired or is given up by big corporations. Only one SME identified as innovative, Industrias Químicas del Vallés, has an active substance registered and synthesises its own molecule in order to produce new phytochemical substances.

The bio–pesticide industry[1]

The bio–pesticide industry covers those firms using biological pest control methods — that is, the use of a specially chosen living organism to control a particular pest. The emergence of this new market is closed linked with political and social pressures for a decrease of the environmental and human health risk of agrochemicals in agriculture. So bio–pesticides could be qualified as an innovation in the plant protection product area. On the other hand, the growth of the bio–pesticides market is linked with the development of the Integrated Pest Management systems (IPM), which may combine bio–pesticides and agrochemicals.

In 1997, the world bio–pesticide market was around USD 200 M and it only accounted for 0.7% of the world crop protection market (*Agrow* Nº271) In that year, insecticides represented 90% of the market, comprising Bt products for 50% of the sales (USD 100M) and macro–biological agents' sales for the other 40%.

According to *Agrow*, the macro–biological sector was highly optimistic in the early 1980s, but has since become over–supplied and unprofitable, with the results that the development of new uses on new crops has stagnated. In 1997, the most widely used agent was the egg parasitic wasp: Trichogramma. Most trichogrammatids were produced by small specialised producers, with low technology and high labour input. The *microbial pesticide market* is highly competitive, with up 45 Bt products. The profitability is mainly linked to low cost production.

In Europe, the bioinsecticides market is also dominated by Bt sales: two companies, with Bt products, represent 86% of the European bioinsecticide market (Novartis and Laboratoires Abbot) In others biopesticides sectors, Laboratoires Abbot dominates with 33% of the market shares, followed by Intrachem and N.P.P. (25% each), then BINAB, MicroBio and BASF (the three together have 17% of the market shares) (AGROW N°287)

Seeds

Producers of seeds have traditionally been small family–owned companies which supplied local markets due to the fact that new varieties have to adapt to the agro–ecological features of the area. The use of biotechnology has had a great influence on seed industry, since the possibility of obtaining new varieties with additional characteristics has drawn the attention of agro–food and agrochemical industries (Bijman, 1999b)

Despite the purchase of many seed companies by agro–food and agrochemical multinational groups and the merger of others, the number of companies is higher than that of the agrochemical sector. There are both big companies and SMEs that supply local markets or keep a dominant position for some of their products.

The characteristics of seed–producing companies, their position in the market and their strategies largely depend on the kind of seed they produce. Multinational companies lead in the case of major crops (corn, soya, cotton, etc) where larger economies of scale can be

[1] All the information on bio–pesticides industry in this report has been provided by the French report on SMEs.

found and biotechnology has been used up to now in most cases. In the case of horticultural crops, competition between large companies and SMEs is higher.

The situation of seed markets is quite different in each of the countries studied. The majority of independent SMEs producing their own varieties are in The Netherlands and in France.

In The Netherlands, there is a long tradition in seed production and keeps a leading position in horticultural and potato seeds. Many of its SMEs have expanded and operate in other European countries. Today, their market share is quite high. However, the largest vegetable seeds companies in the Netherlands are now subsidiaries of foreign multinationals. In agricultural seeds the Netherlands is a small country, although one company belongs to the top five of seeds companies in the world (Advanta) and one company is, despite its relatively small size, truly a global player (Barenbrug). The seeds industry in the Netherlands is a relatively large industry compared to other countries, and has a strong international orientation.

In France, there are about 100 companies involved in the research or the development of new products. These companies can be distributed in 5 different categories: the independent and family owned seed companies (15 companies); the co–operative owned seed companies (37 different business unit, 20 coop groups)[2]; the joint venture between seed companies (8 different units)[3]; the subsidiaries of foreign seed companies (25 business units); and the subsidiaries of pesticide group (10 cases)

Spanish seed companies are mostly family businesses that have adopted a strategy consisting of specialising in meeting specific needs of local markets. Despite the large size of agricultural sector, there exist a lot of seed multiplying companies but relatively few of them obtain new varieties since that is traditionally done by public researchers. Regarding their importance for the national market, we can mention Semillas Fitó (horticultural and garden seeds), Semillas Battle (garden seeds), Semillas Ramiro Arnedo (horticultural seeds) and Agrosa Semillas (cereals seeds) as SMEs marketing their own varieties.

Something similar happens in Denmark, where most national companies are multipliers or have specialised in importing seeds on a licence basis. Only few of the companies, mainly among the smaller ones, are independently owned, but these are generally far too small to be able to invest substantial amounts of money in long–term research and development. The agricultural seed business in Denmark consists entirely of small and medium–sized enterprises. An exception is DLF–Trifolium, with a market share of over 70 per cent in the Danish home market, and a dominant position as a supplier of grass and clover seeds for the European market. DLF–Trifolium has the capacity to develop and market its own traits.

In the United Kingdom, only a few independent companies that make new varieties survive. Just one highly innovative seed producing company has been identified, Elsoms Seeds Ltd, that has some 80 employees and is active in several LINK projects[4] and utilises assisted breeding techniques.

Biotechnology

The so–called biotechnological companies are an additional important element in seeds and agrochemical industry. These companies appeared mainly in the USA at the end of the 1970s with the aim of exploiting financially the scientific findings obtained by academic researchers. These companies have also appeared in Europe but to a lower degree. Among

[2] Generally, these coop have been originally involved in the seed producing business, and the commitment in the breeding business has been part of an upstream diversification of there activity.

[3] Typically, these joint ventures conduct a joint breeding program between different seed companies for a small niche market (e.g. forage crops)

[4] The LINK Programme is the UK Government's principal mechanism for supporting collaborative research partnerships between UK industry and the research base, mainly universities (UK report on SMEs)

the reasons argued for the scarce number of these companies is the relatively small amount of venture capital and the lower scientific– technological capacity (Saviotti et al., 1998) Even so, over the last few years biotechnological companies have been progressively purchased by large seeds–producing or agrochemical companies.

Recently, there has been a significant increase in the number of biotechnological SMEs thanks to assistance programmes of European governments. In the United Kingdom there are two research programmes that have promoted the creation of new companies. The LINK Programme, that supports collaborative research partnerships between UK industry and the research base. SMART is the DTI (Department of Trade and Industry) initiative designed to provide significant financial assistance towards the development of pre–competitive innovative technology. In The Netherlands the Ministry of Economic Affairs has initiated a 45 million Euro subsidy programme (Life Sciences Action Programme) for helping biotechnology start up firms. In Germany, the Federal Government implemented in 1997 the BioRegio–Competition project, which supports regional clusters of expertise in biotechnology. These project was developed in three main regions: the Rheinland (Cologne, Düsseldorf, Wuppertal, Aachen), the Rhein–Neckar triangle (Heidelberg, Ludwigshafen, Mannheim) and Munich. From 1997 onwards, the three regions are receiving preferential funds of DM 50 million each. As a result, 150 new biotechnology businesses were set up in the regions up to the spring of 1998 and over DM 560 million of private capital was invested in biotechnology in these regions. Also, under the umbrella of the Biotechnology 2000 program, there are other projects supporting R&D activities of biotech companies, being Bio–Production, Plant Genome Project and Bio–Profile the most relevant ones for agro–biotech. Other countries, as Belgium, Switzerland and Sweden, have enhanced promotion programmes for biotechnology activities.

Most of these are micro–companies with less than five employees and they have started thanks to university research groups or public research institutions. The main activity of these companies is research and development for other companies since not many of them have the capacity to launch their products to the market. However, many of them have been purchased by multinationals or are part of joint ventures or associations with multinationals. So the number of independent agro–biotech SMEs in the analysed countries is quite small, even in those countries where most of the biotech companies are located (United Kingdom, Germany and The Netherlands)

In The Netherlands, the number of dedicated agricultural biotech companies has always been quite small. According to a publication of the Ministry of Economic Affairs, in 1995 the Netherlands counted more than 40 companies with activities in agricultural biotechnology, of which 22 focussed on field and horticultural crops, 6 on floriculture and 5 on animal production. Of the 22 companies working on plant biotechnology (excluding floriculture) only a few were new dedicated biotechnology firms. Most of the companies working on plant biotechnology (in 1995) were established seed companies. New plant biotechnology firms were Mogen (now Zeneca Mogen), Keygene, Florigene (now Florigene Europe) and RZ Research (no longer existing) Four other seed companies – Cebeco Seeds, Rijk Zwaan, De Ruiter Seeds and Enza Seeds – had direct access to plant biotechnology research, as they were shareholders of Keygene.

In Germany, the Information Secretariat for Biotechnology lists 42 SMEs active in agro–biotech, of which just 19 are involved in developing new seed and plant varieties, while the other 23 provide contract and other supporting services. However, they play a minor role in the development of the German agro–biotech sector (total employment in 19 SMEs active in developing new plants and seed varieties is substantially less than that of the two main German multinationals: AgrEvo and KWS) Furthermore, several experts on German agro–biotech SMEs have stressed their dependence on a few large agro–chemical firms. This constrains their ability to develop their own seed and plant lines and ensures that many of them are limited to providing contract services to the larger firms.

In Denmark, agricultural biotechnology is still carried out mainly by a relatively small group of companies, some of which are far too large to be characterised as SMEs. A number of small pharmaceutical biotechnology companies have emerged over the past 5–10 years.

A recent report from the DTI (1999) supports the widely held view that relatively few SMEs are innovating in agro–biotechnology in the United Kingdom. Most biotechnology SMEs are active in the development of new pharmaceuticals and medical diagnostics technology. There are however, a limited number of companies that are involved in agricultural diagnostics.

In Spain there were not identified any independent firm in the sector of agro–biotechnology, although over the last few years, these companies have appeared in the pharmaceutical and environmental sector. Among its priorities in the Biotechnology National Plan of the R&D National Plan, the Spanish Government anticipates the promotion of new start–up biotechnological companies, but there is no specific economic aid plan for this sector.

2. Innovation Strategies

Agrochemicals

The assessment of innovation strategies of SMEs in the agrochemical sector is difficult because there are very few independent companies and they have little operational capacity due to the oligopolistic characteristics of the market and the long time–periods needed to launch a new product onto the market – some 10 years. Most of the producing SMEs in Europe are limited to being generic producers.

However, two basic lines followed by SMEs in the analysed countries can be identified:

- Integrated Pest Management: just like multinational companies, the SMEs propose the adoption of IPM as a solution to the environmental impact of agriculture[5]. The aim is to give a combination of products and methods that diminish the impact of pest and disease control. That is why SMEs offer a consultancy service for the integrated management of crops and new products based on natural components (bio–pesticides)
- Orientation to specific products for small crops. This defensive strategy has the aim of covering the market niches that multinationals leave. A decisive back–up to this strategy is Directive 91/414 which, as we will see below more closely, makes the SMEs reduce their products catalogue for the lack of financial resources in order to include in the Single European Register the molecules with which they worked previously. High cost of the inclusion of new molecules is also considered to be an important hindrance to innovation since, due to the increasing specialisation in specific crops, the small market size will not allow the recouping of registration cost.

This trend has been observed in some of the analysed companies like Luxan in the Netherlands and Probelte in Spain (see Box 1)

Box 1: Examples of SMEs' innovation strategies in agrochemical sector

Luxan's main activities used to be the formulation and wholesale of pesticides with active ingredients supplied by foreign producers. Due to the concentration among the major pesticides producers and the stagnant market for pesticides, fewer and fewer business opportunities remained for Luxan. Also, for generic products like glyphosate Luxan has become too expensive as a producer. As a result of changing market conditions, Luxan shifted its strategy from formulating and wholesaling to developing and producing its own products. Also, it is shifting from primarily servicing the Dutch market with a broad range of products, to focussing on the European market with a small number of (proprietary) products. The company's profile has changed

[5] In the Netherlands, Nefyto (Dutch organisation for phytopharmacy) promotes the introduction of IPM methods among its associates, giving information about these methods and helping the companies that use them. Similarly, the Danish Crop Protection Association (DP) advocates a strategy of IPM. IPM is seen as the only realistic way of feeding the growing world population in an environmentally benign way.

considerably in the last decade, as it is now less concerned with generic products and more with innovative products. Luxan is investing more in new products, and has an R&D budget of 5% of turnover. The company believes it can better complement the multinationals by concentrating on smaller, niche products.

Another reasons to focus on a small number of products for a large European market are the Dutch and EU registration policies. As environmental policies become more and more tight, fewer products will receive or maintain approval, while registration itself is becoming more and more expensive. According to Agrow (Nº345) pesticide registration fees in the Netherlands are among the highest in Europe. The cost of supporting older registrations and registering new products has led Luxan to withdraw several products and abandon the development of others.

Probelte is a Spanish agrochemical producing company with more than 160 products in its catalogue and a nation–wide commercial network through distributors. It also sells its products in other 20 countries, Latin American and Arab mainly. Its basic activity is the formulation of its products, although it also synthesises active substances. Most of its products are commodities and products without a patent. In order to face competition, Probelte concentrates on its most profitable products (by reducing the number of products in its catalogue), opening new product lines for IPM (Integrated Pest Management) and increasing the amounts of money invested in the research of new formulations through collaborations with PSR's because the scarce financial resources and the high cost of registration prevents them from researching new active substances. Probelte considers that the high cost of revision of active substances may stop the continuation of small crops without specific products and make the monopoly of agrochemicals production sector stronger.

The bio–pesticide industry

As we have seen, bio–pesticide could be characterised as a new sector within the plant protection products industry. In fact, some agrochemicals companies have seen in bio–pesticides a strategic alternative to traditional products. Major players in the agrochemical industry are also major players in bio–pesticides, as Bayer and Novartis. But also there are small local producers highly specialised in one product. In this section we focus in the diversification strategy followed by some agrochemical companies through the creation of a new firm devoted to bio–pesticides. This strategy is illustrated through the case study of Calliope and its subsidiary Nature Plant Protection (N.P.P.) (see Box 2 and French National Report on SMEs)

Box 2. An example of the innovation strategy in the bio–pesticide sector

Calliope is a medium size French company founded in 1979. It is specialised in the production and formulation of chemical pesticides, mainly generic pesticides for foreign markets. In 1989, the company created a subsidiary dedicated to bio–pesticide products: N.P.P.. Before this date, Calliope already had some activities in this sector. The bio–pesticides was a strategic alternative for this company, considering the growing pressures and regulatory constrains on chemical products and the lack of funds to invest on biotechnology. Also, N.P.P. was created to produce the biological elements necessary for Calliope's integrated pest management programmes.

At the beginning, N.P.P. failed with its marketing strategy and product developments. They realised that to be profitable they had to target the traditional markets of plant protection products. They had to develop a biological product so efficient as a chemical product and then use the biological advantages in the marketing strategy.

Now N.P.P. has benefits and face an important market growth. For the next years, they pretend to broad their markets, from local markets to other foreign markets, from minor crops to major crops.

The development of bio–pesticides market seems to be closed linked with the development of IPM, within which bio–pesticides are combined with traditional chemical products. This will allow the extension of bio–pesticides from minor crops and local markets to major crops and foreign markets. Also, as shown by the survey conducted in the PITA project, the development of bio–pesticides seems to be in the hands of SMEs, as most of the planned increase for the next years in the development budget for bio–pesticides is among firms with less than 100 employees. While MNCs expect an increase of their chemical/crop combinations; SMEs that lacking capabilities for biotechnological research will diversify their production towards bio–pesticides (Arundel, 1999)

Seeds

As stated above, seeds companies have traditionally been small local family businesses. However, over the last 10 years some of these companies have grown and become world–wide operators. Some others have been purchased by large agrochemical or agro–food corporations which wanted to have access to the SMEs' genetic material. The SMEs that keep their independence operate with a great uncertainty about the future competition that GM seeds may bring about. Most SMEs do not have the necessary economic resources to invest in biotechnology and consequently they concentrate their efforts in the improvement of a few varieties obtained with traditional techniques or assisted breeding techniques[6].

SMEs are now seeking varieties with new characteristics required by food processors and distributors, as well as pest– and disease–resistant varieties. The special emphasis on pest and disease–resistant varieties could be explained as follows: During the 1960s breeding activities focused on the increase of yields, and agrochemicals covered the treatment of pest and diseases. By now the objective of high yields has been achieved (García Olmedo, 1998, p.101), and higher legal restrictions on the use of agrochemicals have broadened the market for pest and disease–resistant varieties.

All the corporations studied coincide in the essential value of R&D at this moment when trying to get new high quality varieties. However, the position of these companies in the market varies depending on the countries. In the Netherlands, innovation is a strong asset of the seed companies, both in developing new varieties, in breeding and multiplication techniques and in seed treatment (Klein et al., 1992). Key factors for this innovative behaviour have been the support from the public research, the develop of plant breeders rights and a strong demand for high quality products from their customers, both in the national and in the international market. In fact, Dutch companies are more internationally oriented and that largely determines their innovation strategies. However, in Spain most SMEs supply local markets where the needs for new varieties are small. In those markets where they compete with multinationals (e.g. horticultural) research of new products is much more active and companies start to consider it as an essential part of their future strategy. Research activities are basically the adaptation of already existing varieties to local conditions and the finding of new varieties through traditional and assisted breeding techniques.

The following box shows an example of innovation strategy followed by a seeds producing company.

[6] The results obtained by Arundel in the survey conducted in the PITA project shows also that genetic engineering is not yet the leader technology in seed development.

Box 3: An example of an SME's innovation strategy in the seed sector

DLF–Trifolium.– With an annual turnover of more than ECU 100 M and about 340 employees, is by far the largest seed company within the SME group[7]. It supplies over one third of the total grass seed consumed within the European Union, and it was the first company to genetically engineer a herbicide–resistant fodder beet. De facto DLF–Trifolium is an agricultural co–operative. The company – as it is now established – was founded in 1989 when DLF (Danish Farmers Unions' Seeds Supply) bought up the shares in Dansk Frøhandel Trifolium Silo and SN Frø. Before then, these companies co–operated on development activities, which was not very rational: after having developed new or improved traits together, the participating companies found themselves competing in the market–place. Thus, R&D related scale economies contributed to the decision to merge the seed companies.

The company has subsequently expanded substantially through a series of mergers during the 1990s – a process that has been supported both financially and politically by the agricultural organisations. The company is very active in research and development. According to Trifolium's homepage, "*one in every six employees at DLF–Trifolium is engaged in product quality and development. Our overall goal is to increase quality and, at the same time, strengthen reliability of cultivars. We therefore attach a great importance to developing varieties of high quality that can survive under different climatic conditions*". The DLF–Trifolium R & D activities are based at Store Heddinge in Denmark together with activities in France, Ireland and the Czech Republic. The varieties are tested under varying climatic conditions all over Europe, North and South America, Asia, Australia and New Zealand. The major plant breeding programmes include a wide range of grass seed for fodder and amenity, clovers, fodder beet, oilseed rape and peas".

Together with Danisco and Monsanto, DLF–Trifolium has been heavily involved in the development of a roundup–resistant fodder beet. DLF has also set up a common research laboratory with Risø National Laboratory with a view to developing a new type of rye grass without stems. Since the stems are generally hard to digest, grass without stems would have a higher forage value. According to Marketing Director Gunnar Johansen, DLF–Trifolium intends to stick to the production of grass and clover seeds, i.e. to concentrate on developing its core competencies. The company has no plans for expanding into other types of seed production.

Biotechnology

The important role played by new science–intensive SMEs in the emergence of biotechnology sector has been well empirical analysed (being pioneering the studies by Kenney, 1984; Orsenigo, 1989; and Oakey et alia, 1990) A new form of industrial organisation was developed in biotechnological sectors, based on highly science intensive SMEs and inter–institutional collaborative agreements between PSREs, MNCs and SMEs (Saviotti, 1998) The evolution of this industrial organisation has differed between sectors and countries. In Europe, biotech SMEs have played a less important role in the commercialisation of biotechnology than in the US and large companies and PSREs have lead the research and development of biotechnology (Acharya et al., 1998)

Our research shows that European plant biotechnology companies are few in number and are normally associated with seeds or agrochemical companies or have been purchased by one of them. The main factors that have facilitated the acquisitions of SMEs by large firms are: i) the large investments required for biotechnological research together with the lack of external funding; and ii) the uncertainty of the markets for biotechnological products.

[7] DLF is short for *Danske Landboforeningers Frøforsyning*, which means Danish Farmers Unions' Seeds supply.

Even for independent SMEs, it is still very important to them to participate in research networks with similar companies and with larger corporations because that allows them to get funds and it helps their products respond to market demands. Strategic links with seeds and agrochemical companies with a high production capacity is essential for their consolidation. Links with PSREs are also important, especially at the first stages of the companies, because they can have access to the latest scientific advances at a relatively low cost. A further point in the strategy of innovation of these companies is their specialisation in highly advanced technologies, which are a great advantage when competing with other corporations. Hence the importance of copyright protection of research results, although in certain cases the traditional patent system does not fit adequately to the needs of the companies since they are considered time consuming and quite expensive.

Another important common feature of these companies is the fact that they focus their short and mid term strategies in the economic exploitation of their main technologies or competencies, rather than in the expansion of their activities to other fields or technologies.

Most of agro–biotech companies are located in The Netherlands, United Kingdom and Germany. In The Netherlands, initial innovation decisions were influenced by technological expertise developed by universities. In reaction to demands from the seed companies, especially from the potato seed companies, methods to improve pest resistance in crop plants has been an important target of the biotechnology research. At the same time, these firms put a large emphasis on developing technologies that could be commercialised in a broader market, particularly by licensing patented knowledge. Currently, many biotechnology SMEs have been acquired by large agrochemical or seed companies. This is the case for Mogen and Florigene, two of the most important Dutch agro–biotechnological firms. Through such a take over, the companies consider that they have better perspective of continuing their biotechnology research.

In the United Kingdom also many SMEs grow to a point where they are taken over by larger independent companies or MNCs. Indeed, this is sometimes the business strategy of some SMEs, since SMEs are clearly unable to compete directly with MNCs — for lack of resources for innovation and the difficulty in accessing external funding. The access to financial backing which is potentially available from larger companies may be seen as a key to successful product development. SMEs also play an important role as catalysts for innovation, for example as spin–outs from the University sector, providing an initial platform for the commercial development of academic research ideas. Alliances and other collaborative partnerships are critically important to the successful development of SMEs and their technologies, and potentially allowing access to facilities, expertise and other essential technological resources. The remaining independent SMEs need to develop niche products.

German biotech SMEs regard the main barrier for their development to be the unsatisfactory transfer of technology and the lack of regional communication structures and cooperation (Licht and Legler 2000), although there is regional networking and clustering among science, industry and public enterprise support agencies. Also SMEs argue that the present tax system, which operates a disadvantageous depreciation regime for biotechnology investments and limitations on the possibilities for share–options, is a barrier to sustained growth in the industry. The German Venture Capital Association is of the view that there is a lack of comprehensive tax exemptions for capital gains (Schitag, Ernst and Young 1998) Other barriers for the development of agro–biotech companies, pointed out by Dr Hans Jürgen Klockner, head of the new biotech companies unit at the German Association of Biotechnology Industry, are:

- The regulatory hurdles for start–ups. On average, it takes ten times longer to set up a limited–liability company in Germany than in America, and costs three times more.
- Labour markets. Although social charges are high throughout Europe, Germany draws social–security taxes on part–time jobs. This limits the ability of companies to hire part–time workers.
- Lack of cooperation between universities and companies. Enterprising academics suffer severe restrictions on the time they can give to business projects.

- The heavy dependence upon “high risk outsourcing” by smaller firms towards big agro–chemical firms.
- A negative public attitude, especially towards GMOs.

3. Environmental discourse

Political and public opinion pressures to reduce environmental impacts of agriculture has become a very important factor in defining strategies of agricultural input–supplying companies. Even when this pressure has not yielded a large number of new less environmentally damaging products, it must be said that environmental awareness is shown, at least, in the discourse of all the companies. However, attitudes to these pressures differ in the various sectors.

Agrochemicals

The agrochemical sector undergoes more pressure from environmental criteria. And the pressure of the agro–food industry and consumers in order to reduce the level of residual quantities of pesticides in food has become an important feature in the market. The main response of the agrochemical industry is the promotion of IPM, a policy backed up by the European Crop Protection Association. It is based on a combination of agricultural inputs which produce, they said, a lower environmental impact in each type of crop. The IPM is supplemented by some national associations with declarations or protocols of “good practice” for their members, so as to gain the trust of the food sector and consumers.

A strictest environmental regulation, especially Directive 91/414, means a threat against many SMEs which do not know for how long they will be permitted to continue producing the same products. That is why some companies restrict the number of traditional chemical products in their catalogues and try to produce new products based on “natural” substances (bio–pesticides) with a lower environmental impact.

> An example of pressures from the food industry on the agrochemical industry to come up with products with a better environmental profile is the natural sprout inhibitor Talent developed by Luxan (NL) In response to consumer concerns or even legal bans (in some Scandinavian countries), the potato processing industry started to look for an alternative for the commonly used chemical sprout inhibitor. Talent has proven to be a good, though expensive alternative.

The bio–pesticide industry

Bio–pesticide products are, by definition, more environmentally friendly products than chemical ones. However, bio–pesticide are not an alternative to chemical products, but a complement of them in IPM.

According to the N.P.P. Director, a clean product is a balanced product:

- with good technological and efficiency levels;
- respecting environmental norms and food safety constrains;
- fitting with economic constraints ("an ultra–safe product is often an ultra–costly product!")

About the bio–pesticide sector as a new paradigm for plant protection, more environmentally friendly, according to the firm manager, "we should not have a "black and white" attitude. There are now three way for plant protection: chemical pesticides; biological pesticides; and GMOs. All of them have positive and negative impacts and the good way toward sustainable agriculture is to adopt a complementary approach". Using the potential complementarity between Calliope and N.P.P. products, the firms try now to offer a complete scheme of IPM.

They should not isolate bio–pesticides from the traditional pesticide market but, on the contrary, articulate them.

Seeds

In the seed sector, environmental pressure is not a direct influence, although seed companies sometimes find market opportunities related to it. Traditionally, one of the main objectives of seeds companies has been the seeking of pest and disease resistant varieties, together with the seeking of high–yielding varieties. During the Green Revolution, seed companies focused on high yields, given that pests and diseases were covered by agrochemical products. Now, because the yield objective has been achieved, because the environmental pressures for reducing the use of chemical products, and because the doubts about the environmental benefits of GMOs, some SMEs see and "sell" pest and disease–resistant varieties (obtained by the use of classical improvement techniques instead of the biotechnological ones) as “environmental” products.

Biotechnology

In the biotechnological sector, environmental pressure acts in a double direction. On the one hand, European consumers reject biotechnological products, and this is provoking some instability in the companies. On the other hand, the use of biotechnology to reduce the utilisation of polluting chemical substances is considered a great market opportunity. So firms define their strategies with a high degree of uncertainty about the social and legal acceptability of their products. However, the way SMEs manage uncertainty and risk regulation and risk perception depends on several factors[8].

In our research we have found two different broad perspectives, depending on the activities of the company.

1. Companies involved in the development of GM products consider that public and legal barriers to biotechnology will be overcome as time goes by, and as misinformation and fears disappear, because for some problems "there is no alternative technology" (Advance Technologies Cambridge, Ltd., interview). These companies think that MNCs have to lead the information and social acceptance process for biotechnology because they have the financial and managerial resources to do so. Hence SMEs think that they need to wait. We have observed this view in Dutch companies, many of them operating now under the control of MNCs, where the protests of environmental organisations against field trials with transgenic crop plants have made doing these tests quite expensive. As a result, only the largest companies can afford to do these field trials.
2. Companies whose main activities are related to diagnosis and consultancy have integrated sustainability in their discourse, defending the value of biotechnology to understand and resolve many of the current environmental problems. These companies are more actively involved in information and educational activities. This attitude has been observed in some SMEs in the United Kingdom, as CES (Crop Enhancement Systems, Ltd.) whose vision is clearly focusing on the process of moving towards environmental sustainability with more responsible natural resource management. For CES, this is mainly about developing products which offer the potential to provide better information and therefore more informed decision making. It is also about improving environmental monitoring processes and widening the potential for greater confidence in environmental performance of companies and others. By improving environmental monitoring technology, making it more rapid and much simpler, CES hopes a wider range

[8] Tils indicates that "*companies attempt to influence risk perception according to the following criteria: the importance of new biotechnology for the company; the characteristics of the competition; the acceptance sensitivity of the market; the development time for a product; the distance to the consumer; their position within the commercial chain; the product or brands dependency of the company; size and experience of the company in areas such as public affairs and public relations"* (Tils, 1995 cited by Chataway and Assouline, 1998)

of users will be “empowered”, including ‘ordinary’ consumers. CES also wants to move further into an educational process through the development of these technologies, hoping that many students could be involved in, for example, pesticide monitoring or other pollutants (“biotech in action”)

4. Influence of policies on SMEs

In our research we have interviewed SMEs in the three sectors about how they perceive some policies and how these policies influence their decisions on product development, R&D activities and innovation.

Agrochemicals

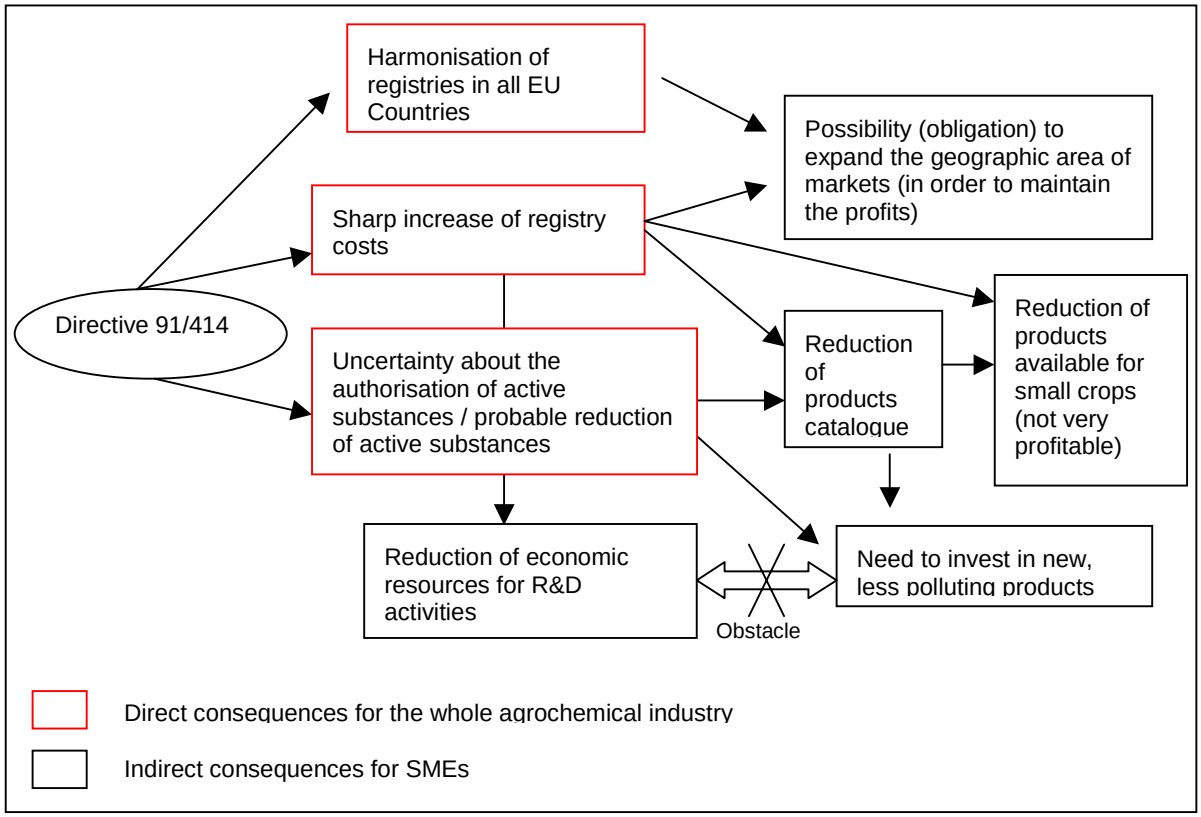
Table 1 shows the perceptions of the analysed SMEs about the influences of the policies that affect their activity.

In this sector, the Directive 91/414/EEC is the one with a high impact, together with other environmental policies. These policies are considered predictable and have the following impacts on decision making.

In the short term Directive 91/414 creates uncertainty as regards the substances that will be included in the Single European Register. This directive demands a re–examination of the active ingredients before the year 2003; that will mean additional expenses for the companies which seek approval of their active substances. The SMEs have very few active substances of their own; the main activity of most of them is formulation of products on the basis of products under licence or without a patent. That is why Directive 91/414 creates much uncertainty for the future of their operation, since the substances that will be finally authorised remain unknown. Besides, high registration costs oblige the SMEs to register only the most profitable active substances and to focus on niche markets, and that means a reduction in the catalogue of the companies (see Chart 1) These reduction of products could mean the disappearance of agrochemicals used only in minor crops. In the short term also, the increase of register costs will reduce the economic resources available for R&D activities.

ANNEX D1

Chart 1. Impacts of Directive 91/414 and consequences on SMEs



In the medium and long term, environmental policies (including Directive 91/414) are making the SMEs consider the production of new environmentally–beneficial products and abandoning traditional harmful products. In the medium term the main handicap to this opportunity is the lack of economic resources that let them start new production lines, a lack partly resulting from a considerable increase of registration costs of active substances (see Chart 1) However, in the long term the companies foresee higher R&D expenditures and more product innovation.

Another impact in the medium/long term on the decision making could be the geographical expansion of SMEs activities, facilitated by the harmonisation of registries in all EU countries, as a way to maintain the level of profits with a smaller catalogue of products.

Regarding the influences on the environmental discourse of SMEs, environmental policies (including Directive 91/414) have stimulated stricter environmental criteria and a greater importance of environmental matters in the decision making process. Companies will seek new environmentally–beneficial products and the promotion of their use within IPMs.

Other policies, as science and technology policies and CAP are also predictable. Whereas CAP does not directly influence SMEs' decisions, science and technology policies have stimulated positive interactions between SMEs and PSREs and universities through alliances and collaborations.

The bio–pesticide industry

The regulatory environment of bio–pesticides is less stringent and less costly than that for chemical pesticides, but country variation is far greater. There is not a harmonised legislation on the register of bio–pesticides at European level, and each country have adopted its own measures[9].

[9] See the French report on SMEs for a broader discussion on this point.

ANNEX D1

Two policies seem to have more influence on bio–pesticides companies: environmental policies and science and technology policies. The stricter environmental protection has encouraged the growth of the bio–pesticide market. However, for those companies whose main activity is the production of generic agrochemicals and bio–pesticides are an alternative product line, the cost of the re–evaluation of all existing active ingredients is so high that they will have to reduce their R&D budgets on bio–pesticides: "The next five years, 40–50% of the R&D budget will be dedicated to the re–evaluation process. The cost of the pesticide registration process disadvantages the small companies: We have less resources to spend to lobby the EC and its bureaucracy." (Calliope interview)

Links with PSREs are also very important. According to the Calliope Director, the links between public research and companies should be strengthened because they have common interests: PSREs have the scientific knowledge, while the firms have the flexibility to develop and market the innovation and the financial resources.

ANNEX D1

Table 1. Policies impacts on the agrochemicals SMEs in the studied countries

Policies	Are policies predictable or uncertain?	What is the interaction of the policies and innovation and R&D decisions?	Impact on the sector	Influences on their environmental discourse	Differences between countries
Directive 91/414/EEC	Predictable, although it creates uncertainty as to the substances that will be included in the single European register and the access to them and the possible reduction of product catalogues	Sharp increase of register costs and, consequently, reduction of resources available for R&D activities Need to concentrate on more competitive products leaving out some which do not sell well or less profitable and need to focus on niche markets Product development for the European market	+++	Greater importance of environmental matters Promotion of IPM The implementation of this directive has stimulated stricter environmental criteria	Spain: Probable disappearance of SMEs if they cannot go on using certain active substances. The Netherlands: The application of this directive has made SMEs reduce their catalogues and expand their geographical activity area; consolidation of companies
Environment	Predictable	Reduction of pesticide waste will promote research and innovation for environmentally–beneficial products More product innovation Higher R&D expenditures Reduction of product portfolio	+++	The environmental factor will become a competitiveness factor	
Science and technology	Predictable	Positive interactions as economic resource and as back up instrument for collaborations and alliances with PSREs and universities	++	No influence	These policies have more and more importance in Spain
CAP	Predictable	No direct influence	+	Agro–environmental measures of *Agenda 2000* are one more claim to reduce the use of agrochemicals	

+++ : considered as the most important by the interviewees; ++ : important; + : significant but not a priority; – : neglictable.

Seeds

Table 2 shows the perceptions of the analysed SMEs in the seed sector about the influences of the policies that affect their activity.

In the seeds sector the legislation is not as influential for the SMEs as in the agrochemical sector. Plant breeders rights legislation has had a positive impact on the sector, reducing the illegal seeds, increasing the profits and bringing an incentive to innovation. This policy in considered positive and predictable.

Environmental policies, including policies for the regulation of plant protection products (Directive 91/414), have a greater influence than we might expect. Higher registration costs for agrochemical products will make it too expensive for producers to register products used only in minor crops. The elimination of certain agrochemicals may provoke the elimination of some minor crops in which some SMEs have a high market share. That is why the SMEs strengthen their research in enhancing pest and disease–resistance in plants for minor crops (see Chart 2). In some countries, like The Netherlands and Denmark, stricter environmental legislation and the promotion of organic farming are opening new opportunities for SMEs that do not produce GM varieties, although the shift to organic farming follow a cautious process.

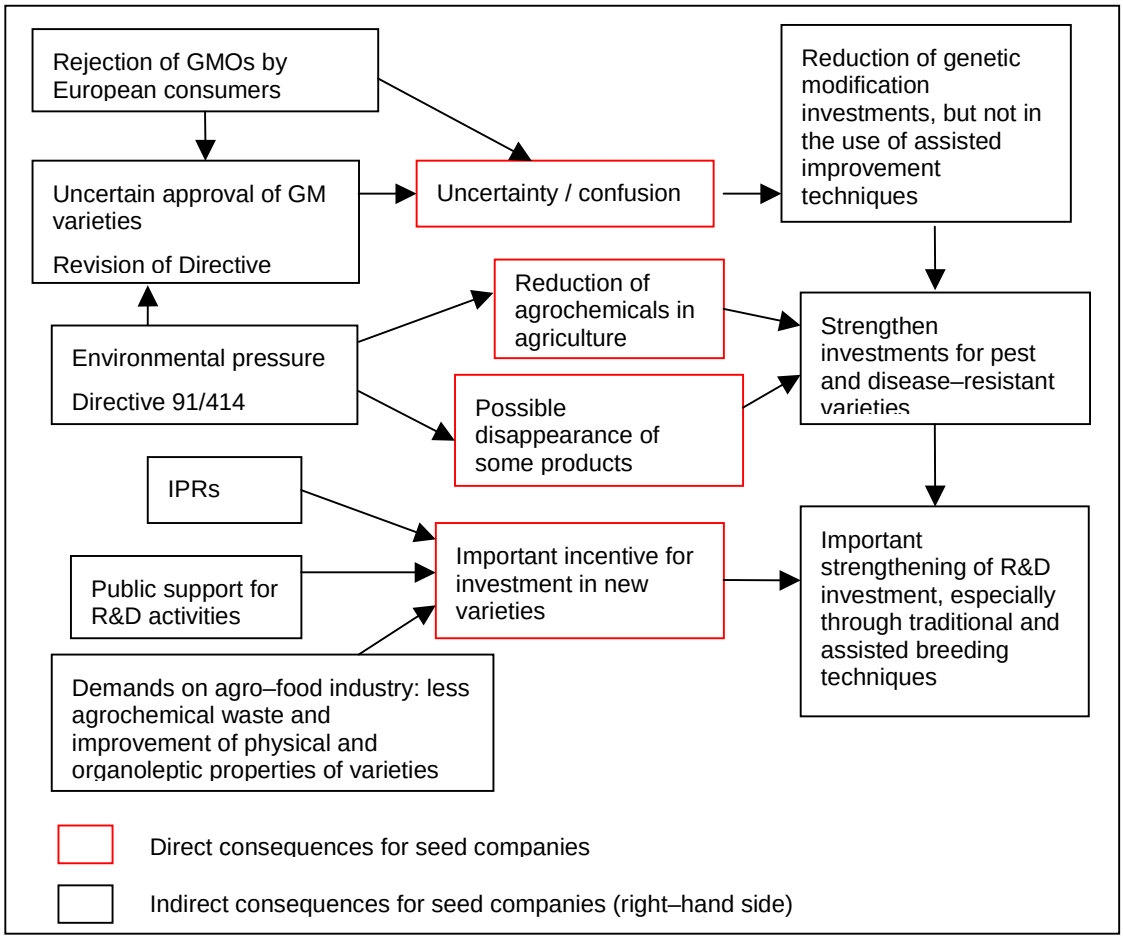


Chart 2. Main influences of SMEs in the seeds sector

GMOs regulation and the lack of agreement between national and European institutions on these technologies provoke a high degree of uncertainty in these companies, and uncertainty provokes a disincentive to invest on biotechnological research (see Chart 2). However, if

the GMOs get the authorisation, then SMEs will have to apply this technology to their products and they will try to invest in order to consolidate their position in the market. In such a case collaborations with PSREs will become more important in order to get funds and the knowledge base required. Whatever the evolution, assisted selection techniques are becoming more and more important. Another concern of SMEs is the time–limited approval of GMOs, that will contradict long–term research and investments plans of plant breeders (see Netherlands report on SMEs)

Another important influence comes from agricultural policy. CAP and *Agenda 2000* may provoke a decrease in the use of agrochemicals through two ways: the reduction in farmland promoted by the set–aside policy, and the cut in farmer's expenditures on inputs stimulated by the shift from price support to direct income payments. Farmers also will have another incentive to reduce or optimise the use of agrochemicals because countries can link the support with environmentally–beneficial practices. Thus, SMEs see higher opportunities for pest and disease–resistant varieties that can substitute agrochemicals or complement them within IPMs.

Environmental and agricultural policies are favouring R&D investment in pest and disease–resistant varieties. In addition, the agro–food industry is demanding less agrochemical waste and the improvement of physical and organoleptic properties of varieties. Thus we can foresee an important strengthening of R&D investment, especially through traditional and assisted breeding techniques, as the market for GMOs remain uncertain.

Finally, science and technology policy seem to be a good sign for these companies' research. In some countries (The Netherlands, Denmark and UK) these policies are focusing on biotech and reducing the support to public agricultural research. SMEs foresee in this trend a shortage of plant breeders and perceive a greater attention to plant resistance research.

ANNEX D1

Table 2. Policies impacts on the seed SMEs in the studied countries

Policies	Are policies predictable or uncertain?	What is the interaction of the policies and innovation and R&D decisions?	Impact on the sector	Influences on their environmental discourse	Differences between countries
Plant Breeders Rights	Predictable	A step forward for research. Seeds control means a reduction of illegal seeds and higher profits for the sector and, consequently it brings an incentive and a higher availability of funds for research	+++	No influence	
Environment (Directive 91/414 included)	Predictable	The reduction of PPP may bring the elimination of certain minor crops. Thus there are incentives for research for the finding of new varieties with a lower input need	++	Spain: Indirect influence on their activity although non–GMOs varieties are presented as an "environmentally–beneficial products" The Netherlands: Cautious shift to organic farming	Environmental policies have more influence in The Netherlands and Denmark, where organic farming is strongly supported, than in Spain and France
CAP and Agenda 2.000	Predictable	A need of research in pest and disease resistant varieties in order to adequate to the possible reduction of expenditure on chemical inputs on the part of the farmer	++	Increasing importance of implementation of agro–environmental measures in extensive cultivation	Their impact on the evolution of Spanish agricultural markets is unpredictable
GMO	Unpredictable	Uncertainty provokes a lower investment on biotechnological research, although the SMEs will try to invest in order to consolidate their position in the market if the GMO's get the authorisation, mainly through collaborations with PSREs. If revision of Directive 90/220 means the provisional approval of GMO's there will be a contradiction with long–term plan of research and investments of the plant breeders	+	GMO is not solution for environment	
Science and technology	Predictable	Positive interactions as economic resource and as back up instrument for collaborations with PSREs. Focus on biotech; shortage of plant breeders; large attention to plant resistance	+	No influence	

+++ : considered as the most important by the interviewees; ++ : important; + : significant but not a priority; – : neglictable.

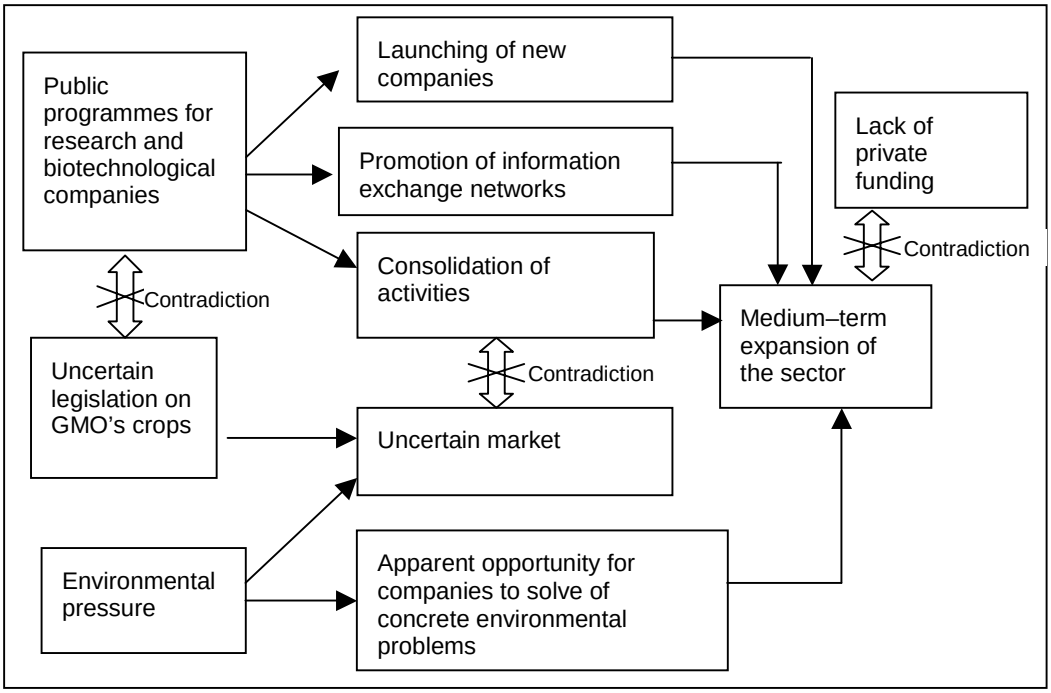
Biotechnology

Table 3 shows the main opinions of SMEs in the plant biotechnology sector about the policies that have a greater influence on their activity.

As we might expect, GMOs regulation has the biggest impact on companies. The revision of Directive 90/220 at European level and the differences in countries and organisms positions create uncertainty about what will be the legislative and policy framework within which SMEs could develop GMOs. The uncertain legislation and the increasing public opinion pressure against GMOs provoke uncertainty about markets for products developed for SMEs.

A serious contradiction is perceived by SMEs between GMO regulation and science and technology policies supporting biotechnology (see Chart 3). The EU and all the studied countries have launched research programmes promoting biotechnological research; some countries even have launched special subsidies programmes for start–up firms[10]. SMEs consider that economic aid has a decisive influence on this sector for companies' first steps and allow the consolidation of their activities. Public programmes are an important source of subsidies for biotechnological SMEs, although the implementation of R&D programmes, especially the European ones, entails much bureaucracy and does not fit the companies' needs. Subsidies are not crucial when the company has reached a certain degree of consolidation, though participation in networks and information exchange are the key reasons for participating in public–funded projects.

Chart 3 Main influences on SMEs in the biotechnological sector



Research and subsidies programmes for the creation and consolidation of biotechnological firms and the promotion of information exchange networks contribute to the medium term expansion of the sector, although the uncertain legislation and markets is a serious obstacle

[10] For example, Dutch Government has approved in the year 2000 a 45 million euro subsidy programme for helping biotechnology start–up firms. In the UK, the SMART programme is specially designed to provide significant financial assistance to SMEs towards the development of pre–competitive innovative technology.

to the consolidation of the SMEs. Other perceived obstacle is the lack of private funding and venture capital for biotech companies. Some European countries are trying to encourage the investments in SMEs, but investments in the middle–stage development of companies is still needed.

Another important policy for biotech SMEs is the IPR legislation. The protection of the products is essential to encourage the investments in this sector. The Directive 98/44 has not clarified some issues like access to genetic resources and the suitability of the patent system to protect biotechnological research. Also, the implementation of the Directive is encountering the reluctance of some countries, and therefore the harmonisation objective is not being achieved. For biotechnological products SMEs demand a patent system which is faster, cheaper and harmonised at European level. However, sometimes biotech patents make it more difficult and costly to commercialise new varieties.

Finally, SMEs foresee in environmental pressures and stricter environmental regulations an important work niche, especially in pest and disease–resistance varieties for minor crops (horticultural crops for example in The Netherlands) and in the solution and improved information provision for environmental problems. In so far as environmental pressures relate to the rejection of GMOs, however, they contribute to the uncertainty. In some countries, where there are stricter environmental legislation, such as The Netherlands and Denmark, these policies are sending clear signals to companies favouring a shift to less environmentally harmful products; in other countries, like the United Kingdom, there is a need to clarify environmental policies, especially building up a consensus on the definition of environmental problems.

ANNEX D1

Table 3. Policies impacts on the biotechnology SMEs in the studied countries

Policies	Are policies predictable or uncertain?	What is the interaction of the policies and innovation and R&D decisions?	Impact on the sector	Influences on their environmental discourse	Differences between countries
GMO	Unpredictable	Increasing uncertainty Incoherent positions of countries (and their Ministries) creates uncertainty and hinders consolidation and opening of new companies	+++	Biotechnology could be a key tool to solve some environmental problems	The Netherlands: If transgenic varieties are not approved, there will be an important jobs loss in these companies
Science and technology	Predictable	Public programmes are an important source of subsidies. Economic aid has a decisive influence on this sector at companies' first steps and allow the consolidation of their activities. However, subsidies are not crucial; participation in networks and information exchange are the main reasons for participating in projects	++	No influence	In The Netherlands SMEs see clearly contradictions between programmes supporting biotechnology and the reluctance to grant approval for GMOs
IPR (patents)	Unpredictable	The need to protect products is essential to the sector. However, the suitability of patent system is unclear; sometimes biotech patents make commercialising new varieties more difficult and costly. A faster access to IPR is needed.	++	No influence	
Environment	Depending on the country, unpredictable or predictable	The Netherlands: strong focus on pest and disease resistance United Kingdom: Environmental problems are seen as potential opportunities for innovations, either as possible solutions or through improved information provision.	++	Developing techniques to enhance pest resistance in crop plants has even become more important over the years Approach to less environmentally harmful products	United Kingdom: Clearer, more predictable environmental policies are needed

+++ : considered as the most important by the interviewees; ++ : important; + : significant but not a priority; – : neglictable.

5. Conclusions

Agrochemicals and seeds are two sectors where biotechnology has a high impact. However, the application of biotechnology in these sectors, and in general in the agro–food sector, has met a greater social opposition and political controversy than in other sectors. Thus, these sectors work within an uncertain environment — about the public acceptance of their products, their markets and the future development of legislation.

SMEs have less capabilities to manage this uncertainty and less financial resources to invest in biotechnology than MNCs, which currently lead the development of plant biotechnology in Europe. Also the oligopolistic character of the agrochemicals and seeds hinder the appearance and consolidation of new firms. As a result we have found very few independent innovative SMEs in these sectors in Europe, even in the case of the so–called biotechnological companies, since many of them have been purchased by larger companies in recent years.

In the case of agrochemicals, there are just a few independent agrochemical–producing companies in Europe; and most such companies are multinational corporations subsidiaries. A few multinational companies control the R&D activities, the discovery of new active ingredients and their production. The processes of formulation, generic production, bottling and distribution are carried out by SMEs. *[correct distinction between roles of MNCs/SMEs?]*

The few independent SMEs are facing a major challenge: the adaptation of their products to the new requirements established by the Directive 91/414 and other environmental policies. The main strategy followed by these companies is the search for new environmentally–beneficial products to be used within IPM methods and the search for niche markets. In that sense, bio–pesticides appear to be an opportunity, both as a niche market and as a complement to agrochemical products within IPMs.

In the case of the seeds sector, the number of independent companies is higher than that of the agrochemical sector. Although most of the SMEs supply local markets, some also maintain a dominant market position for some of their products. The major challenge facing SMEs in this sector is the introduction of biotechnology into their core competencies. Most SMEs only use traditional techniques, and an increasing number of them use assisted breeding techniques, since the GMOs market remains uncertain and they do not have financial and managerial resources to cope with biotechnology. The main strategy followed by these SMEs is to concentrate on developing a few varieties for local markets, by strengthening their R&D investments, especially targeting pest– and disease–resistant varieties, in response to environmental and agricultural policies and agro–food industry demands for the reduction of agrochemical usage in agriculture.

In the case of biotechnological companies, the number of independent agro–biotech SMEs in the analysed countries is quite small; many of them have been purchased by multinationals or are part of joint ventures or associations with multinationals. The main activity of these companies is research and development for other companies, since not many of them have the capacity to launch their products onto the market. The main constraints to their development are the uncertain regulation of GMOs, the lack of external funding, the public rejection of GM products and, consequently, the uncertain market.

For biotechnology SMEs, their main strength lies in alliances and networks — with PSREs, in order to gain access to the latest scientific advances; and with MNCs, to ensure that their products respond to market demands and to cope with uncertainty, given that MNCs have the financial and managerial resources to maintain a long–term strategy. Independent SMEs try to strengthen the economic exploitation of their technologies rather than to broaden the scope of their activities, and also to find niche markets left by MNCs. In that sense, solutions to environmental problems are seen as a market opportunity for SMEs and to the development of biotechnology, especially for those companies involved in consulting and information services.

In the three studied sectors the role of SMEs in the innovation processes is quite small, especially in those processes that imply the use of biotechnology, although some opportunities are emerging related to solutions to environmental problems.

Public policies have had an important impact on the activities of SMEs, especially Directive 90/414 and environmental policies in agrochemical companies, IPR in seeds companies, and GMOs legislation and STI policies in biotechnological companies. In the future, these policies will continue influencing SMEs activities, although it is difficult to foresee what will be the influence of public policies on the innovative role and competitiveness of SMEs, especially because market–related factors have a more direct impact on them.

However, policies to strengthen innovation in SMEs should be introduced.

(i.) First, policies should reduce the uncertainty surrounding these activities — not only those aspects related to GMOs regulation, but also the design and implementation of environmental policies. Companies perceive a clear signal for developing environmentally–beneficial products but without any common concepts (such as sustainability, environmental damage, etc.), nor without any common indicators to assess these products. A clear environmental policy framework is needed to help SMEs to cope with uncertainty and to encourage the observed trend towards products and technologies with environmental benefits.

(ii.) Second, public support for research activities is still needed. SMEs have highlighted the importance of this support and the links with PSREs for their own research, since a main constraint to innovation is the lack of financial resources. In the coming years there is a need to support new high technological firms, and the diffusion of the new technologies within the existing firms. There is also a need to strengthen PSREs — not only their biotechnological capabilities, but also their role as suppliers of basic and new knowledge, especially for understanding and solving environmental problems.

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Executive Summary

This report analyses the role of SMEs from six European countries in the innovation processes in the agrochemical, seeds and biotechnological sectors, especially how policies and market-related factors influence their strategies.

There are very few independent innovative SMEs in these sectors in Europe, even in the case of the so-called biotechnological companies, since many of them have been purchased by larger companies in recent years.

The role of these SMEs in the innovation processes is quite small, especially in those processes that involve the use of biotechnology, although some opportunities are emerging related to solutions to environmental problems.

In the case of agrochemicals, the few independent SMEs are facing a major challenge: the adaptation of their products to the new requirements established by the Directive 91/414 and other environmental policies. The main strategy followed by these companies is the search for new environmentally-beneficial products to be used within Integrated Pest Management systems (IPMs) and the search for niche markets. In that sense, bio-pesticides appear to be an opportunity, both as a niche market and as a complement to agrochemical products within IPMs.

In the case of seeds, the major challenge facing independent SMEs is the introduction of biotechnology into their core competencies. The main strategy followed by these SMEs is to concentrate on developing a few varieties for local markets, by strengthening their R&D investments, especially targeting pest- and disease-resistant varieties, in response to environmental and agricultural policies and agro-food industry demands for the reduction of agrochemicals usage in agriculture. Since the GMOs market remains uncertain and SMEs do not have financial and managerial resources to cope with biotechnology, most of them only use traditional techniques, and an increasing number of them use assisted breeding techniques.

In the case of biotechnology, the main activity of SMEs is research and development for other companies, since not many of them have the capacity to launch their products onto the market. The main constraints on their development are the uncertain regulation of GMOs, the lack of external funding, the public rejection to GMOs products and, consequently, the uncertain market. For biotechnology SMEs, their main strength lies in alliances and networks – with PSREs, in order to gain access to the latest scientific advances; and with MNCs, to ensure that their products respond to market demands and to cope with uncertainty, given that MNCs have the financial and managerial resources to maintain a long-term strategy. Independent SMEs try to strengthen the economic exploitation of their technologies rather than to broaden the scope of their activities, and also to find niche markets left by MNCs. In that sense, solutions to environmental problems are seen as a market opportunity for SMEs and for the development of biotechnology, especially for those companies involved in consulting and information services.

Public policies have had an important impact on the activities of SMEs, especially through Directive 90/414 and environmental policies in agrochemical companies, IPRs in seeds companies, and GMOs legislation and STI policies in biotechnological companies. In the future, these policies will continue to influence SMEs activities, although it is difficult to how public policies will influence the innovative role and competitiveness of SMEs, especially because market-related factors have a more direct impact on them.