Plant Biotechnology: Potential Impact for Improving Pest Management in European Agriculture

A Summary of Three Case Studies
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This summary is the first release of information from a research project that, upon completion, will include 15 case studies for Europe. The remaining 12 case studies will be periodically released during the next year with the release of the final complete report in June 2004. The final report will include:

- Maize-Insect Resistant
- Sugarbeet-Herbicide Tolerant
- Potato-Fungal Resistant
- Tomato-Virus Resistant
- Stone Fruit-Virus Resistant
- Wheat-Fungal Resistant
- Cotton-Insect Resistant
- Cotton-Herbicide Tolerant
- Rapeseed-Herbicide Tolerant
- Rice-Insect Resistant
- Rice-Herbicide Tolerant
- Maize-Herbicide Tolerant
- Wheat-Herbicide Tolerant
- Potato-Insect Resistant
- Citrus-Virus Resistant

Conversions

2.47 Acres = 1 Hectare

2.2 Pounds = 1 Kilogram

Introduction

Crop biotechnology has been widely discussed for the past decade. While the United States has planted millions of acres with genetically modified crops, in Europe, only Spain has any commercial biotech acres. The European Union and European countries are considering a variety of biotechnology regulations while a moratorium on approval of new biotech crops maintains the status quo. Questions remain about the potential impacts on agricultural production if biotech crops were to be commercialized in Europe. Although a number of researchers have released studies of the potential impact of certain biotech crops in individual countries, no single study has used a consistent methodology to estimate multi-crop biotech adoption in multiple European countries.

In 2002, the National Center for Food and Agricultural Policy (NCFAP) released a study that estimated the current and potential impacts of biotechnology in the United States by examining 40 case studies to project economic impacts for 47 states. The U.S. study focused on biotech crops that would improve pest management for weeds, insects and plant diseases. During the research, NCFAP noted that many of the same crop pests were present in Europe and that European researchers were testing biotech crops for managing the pests.

In the fall of 2002 and spring of 2003, NCFAP received funds from Monsanto, Syngenta and BIO to estimate the potential impacts of biotech crops on European agriculture. NCFAP's proven methodology and strong ties to European researchers made it an ideal organization to conduct the first comprehensive study of how biotechnology could impact European agriculture.

Methodology

The same methodology that NCFAP researchers used in its U.S. study (available at www.ncfap.org) is employed in the European study. Case studies have been selected based on information that successful transformation of a crop has occurred and for which there are at least preliminary results for pest management purposes under European conditions. For each case study, NCFAP reviewed scientific literature, internet web sites and data from university and government research facilities. NCFAP interviewed European researchers who are testing biotech varieties, and they provided summaries of their research. NCFAP quantified the current use of pesticides, crop losses and costs of managing each pest problem in several countries by crop. Researchers estimated the acreage on which the biotech crop would be planted based on comparison of growers' costs.

Economic impacts were analyzed in three categories: estimated changes in yield, changes in production value and changes in production costs, which were used to calculate changes in net income. Pesticide use changes were also calculated. Written case study analyses were sent to outside reviewers for comment. The reviewers' comments were incorporated into the case study reports.

Key Findings

The widespread adoption of plant biotechnology in maize, sugarbeet and potato crops in Europe would result in significant yield increases, savings for growers and pesticide use reductions. All together, the three biotech crops would increase yields by 7.8 billion kilograms per year, increase grower net income by €1 billion per year and reduce pesticide use by 9.8 million kilograms per year, compared with existing practices that would be replaced. Among the three crops, the greatest yield increase would come from biotech sugarbeets (+5 billion kilograms) while the greatest reduction in pesticide use (-7.5 million kilograms) and increase in net income (+€417 million) would be realized with the biotech potato. Each of the biotech crops would be planted on more than 1 million hectares in Europe.

Potential impacts of the biotech crops were analyzed for individual countries. Four countries were included in the maize analysis while eight countries were analyzed for sugarbeets and 12 were included in the potato analysis. Overall, France and Germany would see the highest potential economic impacts; growers in each country would gain more than €200 million in net income. Pesticide use would decline by more than 1 million kilograms in France, Germany, the United Kingdom and the Netherlands.

Table 1: Potential Impact by Crop

Crop	Trait	Adoption (000 Hectares)	Pesticide Use (000 Kilograms)	Yield (Million Kilograms)	Income (€ Million)
Maize	Insect Resistant	1,599	-53	+1,899	+249
Sugarbeet	Herbicide Tolerant	1,688	-2,208	+5,050	+390
Potato	Fungal Resistant	1,164	-7,513	+858	+417
Total		**4,451**	**-9,774**	**+7,807**	**+1,056**

Table 2: Potential Impact by Country

Country	Adoption (000 Hectares)	Pesticide Use (000 Kilograms)	Yield (Million Kilograms)	Income (€ million)
Austria	23	-110	+14	+6
Belgium	160	-751	+351	+60
Denmark	98	-386	+181	+29
Finland	30	-144	+15	+8
France	1,364	-1,620	+2,579	+265
Germany	842	-2,783	+1,711	+219
Ireland	14	-108	+9	+5
Italy	874	-547	+1,196	+155
Netherlands	272	-1,362	+490	+114
Spain	406	-317	+663	+74
Sweden	32	-154	+18	+12
United Kingdom	336	-1,492	+580	+109
Total	**4,451**	**-9,774**	**+7,807**	**+1,056**

Case Study: Insect Resistant Maize

Maize is the domesticated form of a wild grass originally from Mexico. Early explorers brought maize seeds to Spain, and, thereafter, the plant spread throughout Europe.

European farmers produce 40 billion kilograms of maize on 4.0 million hectares with a value of €5.3 billion/year. Four countries (Italy, France, Spain and Germany), account for 88 percent of European maize production. Among the insect pests that cause damage to maize, two species of corn borer are of particular importance in Europe: European corn borer and Mediterranean corn borer. The feeding of the borers results in reduced plant growth, reduced kernel size, and harvest losses due to broken plants. Secondary infections of fungi and bacteria are other risks associated with corn borer feeding. Research in France has shown that yield losses to corn borers can be as high as 15 percent while in Spain the losses can be as high as 30 percent. Corn borer control is extremely difficult. Once they enter the stalk, they cannot be controlled with insecticides. Currently, insecticide treatments are made to only 32 percent of the hectares in Europe where borers are a problem. As a result, it has been estimated that Europe loses five percent of its maize production annually to uncontrolled borers.

Through genetic engineering, Bt maize, which kills the corn borers when they feed on the plant, has been created with a gene from a soil bacterium. Bt maize was approved for planting in Europe in the 1990s. Research in Europe has shown that borers cause nearly no yield reduction in the Bt maize plots. Bt maize yields have consistently been 15 percent higher than conventional corn treated with insecticides under European conditions. Research has also shown that Bt maize varieties are significantly lower in toxin contamination levels than conventional varieties.

Due to a voluntary agreement, Bt maize is currently only planted on 25,000 hectares in Spain. A recent study in Spain showed that Bt maize improved profitability by 13 percent. Table 3 estimates the potential impact of planting Bt maize in Europe on hectares that are highly infested with corn borers. Total adoption is projected at 1.6 million hectares (41 percent). Bt maize would substitute for 53,000 kilograms of insecticide use and maize production would increase by 1.9 billion kilograms due to improved borer control. Net grower income is projected to increase by €249 million due to the value of increased production minus the cost of the technology.

Table 3: Potential Impact of Insect Resistant Maize

Country	Projected Adoption (000 Hectares)	Pesticide Use (000 Kilograms)	Yield (Million Kilograms)	Net Grower Income (€ Million)
France	765	-6	+857	+101
Italy	554	-1	+607	+107
Spain	181	-45	+254	+28
Germany	99	-1	+181	+13
Total	**1,599**	**-53**	**+1,899**	**+249**

Case Study: Herbicide Tolerant Sugarbeet

Beet became a source of refined sugar in 1747 when a German scientist first extracted crystalline sugar from the root. Extensive sugarbeet planting began in mainland Europe during the Napoleonic Wars when the British Navy blockaded French ports, preventing sugarcane imports. By 1880, sugarbeets were the main source of European sugar. Sugarbeets are grown on 1.6 million hectares in Europe. European Union growers produce 115 billion kilograms of sugarbeets, which are processed into 15 billion kilograms of white sugar. The value of sugarbeets to European Union farmers is approximately €4.7 billion per year.

Weeds occur in all European sugarbeet fields at levels that would cause crop failure. In fact, competition from uncontrolled weeds can reduce root yields by 26 to 100 percent. Currently, no single herbicide controls all of the weeds found in Europe's sugarbeet fields. As a result, numerous herbicide applications are made every year to kill weeds. Typically, four to five applications of herbicides are made to the typical sugarbeet field at a total cost of €197 per hectare and a total use of 3.2 kilograms of chemical per hectare. Some of the herbicides that are applied to sugarbeet fields can harm the crop. It is estimated that sugarbeet production is lowered by five percent due to herbicide damage to the crop.

Sugarbeets have been genetically modified with a gene from a soil bacterium to be resistant to glyphosate, a broad-spectrum herbicide. Field research in each of the major European sugarbeet-growing countries indicates that two applications of glyphosate are highly effective in controlling weed infestations with no crop damage. The use rate of glyphosate would average 1.9 kilograms per hectare, and the cost of the biotech weed control program would average €86 per hectare.

Adoption of the biotech herbicide tolerant sugarbeet on 100% of the European Union's hectares would reduce herbicide use by 2.2 million kilograms while increasing production by five billion kilograms of beets due to reduced crop damage. Net grower income would be increased by €390 million. Table 4 displays the aggregate impact estimates for major sugarbeet-producing countries.

Table 4: Potential Impact of Herbicide Tolerant Sugarbeet

Country	Projected Adoption (000 Hectares)	Pesticide Use (000 Kilograms)	Yield (Million Kilograms)	Net Grower Income (€ Million)
United Kingdom	171	-222	+450	+41
France	437	-350	+1,600	+98
Germany	461	-921	+1,300	+116
Netherlands	110	-66	+350	+34
Belgium	98	-255	+300	+25
Italy	242	-218	+550	+35
Spain	109	-98	+350	+29
Denmark	60	-78	+150	+12
Total	**1,628**	**-2,208**	**+5,050**	**+390**

Case Study: Fungal Resistant Potato

Spanish explorers brought the potato to Europe from the Americas in the 16th century. The potato was not accepted as a food in Europe for many years because Europeans believed that potato was unnatural and poisonous. Today, European farmers produce 44 billion kilograms of potatoes on 1.16 million hectares with a value of €5 billion.

A fungus causes a disease of potatoes known as late blight. Infected potatoes emit a distinctive unpleasant odor due to decay of plant tissue. Late blight first appeared in Europe in 1845 and had devastating consequences, particularly in Ireland, where peasants were entirely dependent on potatoes for food. Approximately 40 percent of the Irish potato crop was destroyed in 1845 with 100% destruction in 1846 resulting 1.5 million deaths and the emigration of an equal number of Irish to America. Late blight continued to be a major problem until the 1880s when the first fungicide (copper) was discovered.

Potato growers in Europe spray synthetic chemical fungicides eight to fourteen times a year at a cost of €322 per hectare to kill the late blight fungus. Despite these sprays, the fungus destroys about two percent of the European potato crop.

Biotech researchers are focusing on a wild plant species related to potato that exhibits complete resistance to late blight. Genetic engineering techniques have been used to transfer the resistance gene into potato plants. Transformed potato plants have been unaffected by late blight.

Successful introduction of a biotech late blight resistant potato on 100% of European acreage would eliminate the need for 7.5 million kilograms of fungicides and increase production by 858 million kilograms. Grower net income would increase by €417 million. Table 5 displays these impact estimates for individual European countries.

Table 5: Potential Impact of Fungal Resistant Potato

Country	Projected Adoption (000 Hectares)	Pesticide Use (000 Kilograms)	Yield (Million Kilograms)	Net Grower Income (€ Million)
Austria	23	-110	+14	+6
Belgium	62	-496	+51	+35
Denmark	38	-308	+31	+17
Finland	30	-144	+15	+8
France	162	-1,264	+122	+66
Germany	282	-1,861	+230	+90
Ireland	14	-108	+9	+5
Italy	78	-328	+39	+13
Netherlands	162	-1,296	+140	+80
Spain	116	-174	+59	+17
Sweden	32	-154	+18	+12
United Kingdom	165	-1,270	+130	+68
Total	**1,164**	**-7,513**	**+858**	**+417**

Conclusions

Crop pests need to be controlled in order to maintain high yields. If inadequate pest control lowers crop yields, more land is required for crop production. Currently in Europe, regular, multiple pesticide applications control weeds in sugarbeets and potato diseases, which prevent all but two to five percent yield losses. European maize growers do not regularly use insecticides to control corn borers, and Europe loses five percent of its maize production to borers annually.

Genetically engineered crops have the potential to reduce crop losses to pests in comparison to current practices due to their high degree of effectiveness. Three biotech crops were analyzed for their potential to improve pest management in Europe.

- Insect resistant maize has been approved by the European Union, but a voluntary agreement restricts its planting to 25,000 hectares in Spain where it has improved maize profitability by 13 percent. If European maize growers were given access to the technology, the insect resistant maize would likely be planted on 41 percent of Europe's maize hectares increasing production by 1.9 billion kilograms.
- The European Union has not approved herbicide tolerant sugarbeets although they have been extensively tested for agronomic performance throughout Europe. The biotech sugarbeets would allow growers to control weeds with just two herbicide applications in comparison to the four to five applications they currently make. Not only would growers realize significant cost savings, but they would also realize higher yields of five percent due to less crop damage.
- Fungal resistant potatoes are in the research and development stage. However, initial results show that the biotech potatoes have complete immunity to late blight, a disease of potatoes that requires European growers to make eight to twelve fungicide applications yearly. Overall, fungicide use of 7.5 million kilograms could be replaced with the biotech potato.

Growers adopt new technology when it improves their financial conditions. US growers are planting 80 million acres with biotech crops because improved pest control at lower cost has improved their bottom lines. European farmers face the same pests and could experience the same improved pest control and cost savings.

In addition, biotech crops could make it possible for European countries to produce the same amount of food on fewer hectares. The three biotech case studies included in this report would all lead to increased yields: maize (five percent), sugarbeets (five percent) and potatoes (two percent). Instead of increasing yields on all planted hectares, an equivalent portion of hectares could be taken out of production and overall production would stay the same. In total, 329,000 hectares could be removed from production while maintaining yields. In maize, the result would be five percent or 225,000 hectares; sugarbeet growers could reduce production on 81,000 hectares or five percent, and potato production could cease on 23,000 hectares or two percent.

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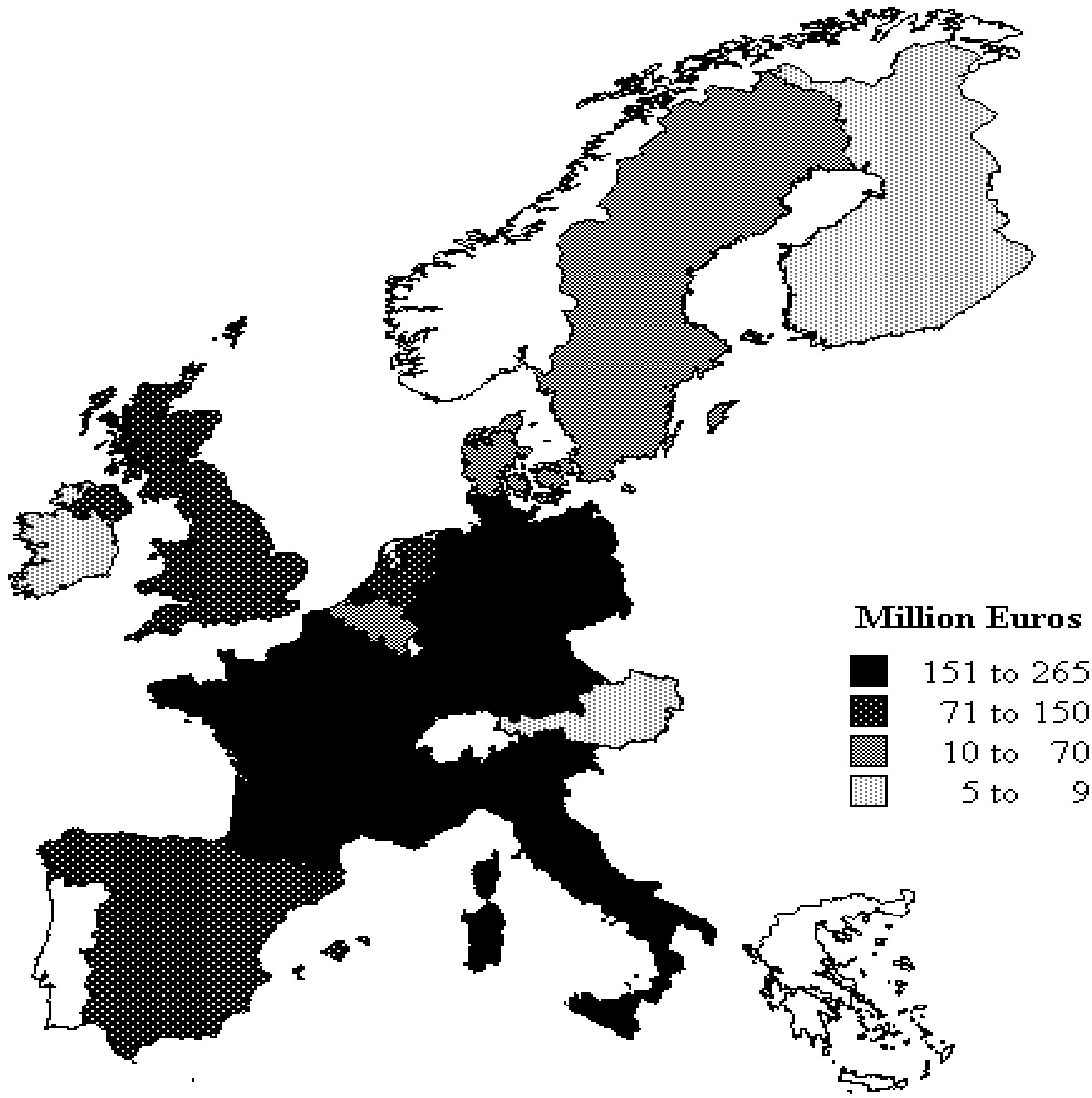
Reviewer

Piet Schenkelaars of Schenkelaars Biotechnology Consultancy, Leiden, the Netherlands reviewed the case studies and provided many useful suggested revisions.

Figure 1: Potential Net Farm Income Increases
Three Biotech Case Studies (Maize, Sugarbeet and Potato)



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