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Agricultural Biotechnology

World, United States & Iowa Perspective

Presented to the Interim Committee on Agricultural Biotechnology

Friday, October 21, 2005

By Doug Getter, Executive Director

Iowa Biotechnology Association

The Iowa Biotechnology Association is a young organization of over 80 life science companies, academic institutions and others interested in the growth and development of life sciences in Iowa.

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On behalf of the members of the Iowa Biotechnology Association, it is my pleasure to be with you today. My remarks will focus on the economic benefits achieved during the ten years agricultural biotechnology has been available in the marketplace. We will begin with a brief review of the scientific history, a look at the world implications, the benefits derived in the United States and the role agricultural biotechnology has in Iowa.

The scientific basis for today's genetic research and applications dates back to 1859 and Dr. Gregor Mendel, known as the father of modern genetics. Working with seeds for his garden, he created a first generation hybrid that retained uniform and desirable characteristics of the parent seed.

Adapting agricultural commodities to new products was the focus of work by George Washington Carver during the 1890's and early decades of the 1900's. In the mid-1920's, Henry Wallace and Roswell Garst formed an alliance to develop and market hybrid seed corn. In 1973 the scientific use of recombinant DNA was perfected.

In the mid-1980's, Dr. Robert Thornburg at Iowa State University prepared a transgenic tobacco plant expressing a gene derived from a potato plant. This work lead to the first field trial of transgenic plants ever conducted at a public institution. In 1996, the first genetically improved crops were planted commercially. Building on centuries of science, biotechnology has become a collection of tools used to improve and enhance plants, animals and micro-organisms for the benefit of society.

Why is biotechnology important to the world as well as to agriculture? Today, approximately 6.4 Billion people populate the Earth, requiring nearly 6 Billion tons of food each year. Forecasters anticipate the world population growing at least 50% by 2050. Given the current consumption rate, the world population will demand 9 Billion tons of annual food production. Limited land and water resources will restrict where and how our food will be produced. If several countries simultaneously endure severe drought conditions, weeds, pests and plant diseases could make the feeding of the world an extremely difficult task. We must continue to find ways to increase production on current acreage if we hope to feed the growing global demands. For example, since 1980, global corn acres have increased 4.8%, while global corn production has increased 45%.

Let's hear what Dr. Norman Borlaug, 1970 Nobel Prize winner for the 'Green Revolution' and farmers from around the world have to say regarding agricultural biotechnology. (Note: this is where a short video will be played.)

A new study released a few days ago entitled, *GM Crops: The Global Economic and Environmental Impact - The First Nine Years 1996-2004,* was published in the peer-reviewed journal, *AgBioForum* (www.agbioforum.org). The report, prepared by Graham Brooks and Peter Barfoot, quantifies the cumulative economic and environmental impacts of biotechnology-improved crops.

Comparing pesticide use with improved crop varieties versus conventional varieties, the authors found, since 1996:

** the use of pesticides in conjunction with improved crop varieties reduced useage by 379 million pounds;
** carbon dioxide emissions have been significantly reduced as biotech crops require fewer trips through the field (a reduction of over 22 Billion pounds in 2004);
** increased global farm income by over $27 Billion.

In 2004, the Int'l. Service for the Acquisition of Agri-Biotech Applications (with Centers in Ithaca, NY; Nairobi, Kenya; and Manila, Philippines), Fondazione Bussolera Branca, Italy and The Rockefeller Foundation (USA) sponsored a study: "Global Status of Commercialized Biotech/GM Crops: 2004." The author of the study is Clive James. The primary conclusions from the study were:

** From 1996-2004 the cumulative worldwide acreage planted to biotech crops was 951 million acres;
** Biotech crops in 2004 were planted by farmers in 17 countries (fourteen countries growing over 50,000 hectares: USA, Argentina, Canada, Brazil, China, Paraguay, India, South Africa, Uruguay, Australia, Romania, Mexico, Spain and the Philippines);
** 90% of the 8.25 million farmers growing biotech-enhance crops were from resource-poor developing countries whose increased incomes from biotech crops contributed to the alleviation of poverty;
** In 2004, 56% of global hectares planted to soybeans, 28% of the global cotton plantings, 19% of the canola and 14% of the planted maize (corn) were genetically improved varieties;
** The global value of biotechnology crops was $4.7 Billion.

Internationally, the United States has led the scientific advances in and production of agricultural biotechnology crops. The National Center for Food and Agricultural Policy issued in October 2004 a report, "Impacts on U.S. Agriculture of Biotechnology-Derived Crops Planted in 2003, An Update of 11 Case Studies." The authors of the report, Dr. Sujatha Sankula and Edward Blumenthal studied the impact on the following crops: canola, cotton, field corn, papaya, soybeans and squash. Among their key findings were:

** Crops developed through biotechnology provide higher yields (5.3 Billion pounds), higher farm income (saved growers $1.5 Billion), reduced pesticide applications (46.4 million pounds);

** 42 states grew one or more of the enhanced crops;

** Iowa led the country in production from biotech crops (1.08 Billion pounds),

** Iowa led the country in financial impact ($239 million),

** Iowa set the pace in reducing pesticide usage (7.5 million pounds);

In December 2003, Dr. C. Ford Runge released the report, "The Economic Status and Performance of Plant Biotechnology in 2003: Adoption, Research and Development in the U.S." His work focused on eight crops: corn, soybeans, cotton, rapeseed/canola, wheat, potatoes, sugar beets and rice. The primary conclusions from this work were:

** Adoption rates for biotech-enhanced crops are a direct result of increased farm profits (based on 2003 this could be as high as $60/acre for corn, $15/acre for soybeans, to several hundred dollars/acre for cotton);

** Main research & development activities in plant biotechnology are conducted by large private companies, which invested $2.7 Billion in R & D in 2002;

** Economic impacts of plant biotechnology are increasing beyond the farm gate and in states active in biotechnology R & D;

** Iowa led the U.S. in 2002 value of biotech crops for Iowa farmers at $3.8 Billion.

Scientific safety evidence has validated biotech-enhanced crops. In Oct. 2001 the European Commission summarizing 81 biotech research reports concluded, "...the use of more precise technology and greater regulatory scrutiny probably make them even safer than conventional plants and foods." 25 Nobel Prize winners and more than 3,400 leading scientists from around the world have expressed their support for plant biotechnology as a "powerful and safe" way to improve agriculture and the environment. Among the scientific organizations supporting the development of agricultural biotech are the World Health Organization, the Food & Agricultural Organization of the UN, the National Academy of Sciences, the Royal Society (UK), the American Medical Association, the French Academy of Medicine, the Scientific Committee of the European Commission, the Society of Toxicology and the Institute of Food Technologists.

Iowa has established itself nationally and internationally as a vital and critical element of agricultural biotechnology advances. Research initiatives at Iowa State University's Plant Sciences Institute are focused on the advancement of new crop traits and product development. Building on the legacy of George Washington Carver and Dr. Robert Thornburg and the research activities of several major seed companies, the state is positioned well for cooperative worldwide research activities.

Several years ago the Iowa General Assembly defined biotechnology as a target-industry for economic growth. As an example, the fermentation industry is on an aggressive growth track to assist the country with renewable ethanol fuels and the development of soy-diesel. New applications in processing commodity agriculture are leading to new neutraceuticals and bio-based products.

Enactment of the Iowa Values Fund has provided a new financial stimulant that can be available of biotechnology-based businesses. Creation of the public/private/academic Bioscience Alliance within the Iowa Department of Economic Development is providing a common council for discussion/coordination.

In your notebook you will find the executive summaries of the studies referenced in these remarks. In addition, you will find background information from several items prepared by the Iowa Biotechnology Association and the Biotechnology Industry Organization. Complimenting these materials is information on the co-existence that is possible for conventional, organic and genetically improved crop varieties. The National Association of State Departments of Agriculture asked and received a clarifying letter from USDA concerning organic agriculture and biotechnological agricultural methods (a copy of the request letter and response letter are included). Also included in the notebook are two other reports "Co-existence of GM and non GM crops: current experience and key principles" and "Suggested Best Management Practices for the Coexistence of Organic, Biotech and Conventional Crop Production Systems." An article on the feed safety of biotech crops from the February 6, 2004 issue of *Farm and Ranch Guide* outlines work done at the University of Nebraska on livestock feeding or grazing on genetically enhanced corn.

Last week Iowa and Des Moines served as the international focus for food research, discussion and understanding. The World Food Prize celebrated its 19th anniversary and laureate award presentation/symposium. Over 600 individuals from around the world attended the laureate ceremony. Co-founded by Iowa native and Nobel Prize winner Dr. Norman Borlaug, the World Food Prize Symposium provides an excellent forum for discussing the issue impacting the feeding of the world, both present and future. At a meeting with embassy officials from several African nations, Florence Wambugu, from Africa Harvest (funded in part by a grant from the Bill & Melinda Gates Foundation) told the group, "Africa was bypassed by the Green Revolution. We should not let this bypass us."

In the October 14th edition of the *Wall Street Journal,* Dr. Borlaug and former President Jimmy Carter offered a guest editorial, "Food for Thought." Here are a few key thoughts they expressed in the editorial:

> " The past 50 years have been the most productive period in global agricultural history, leading to the greatest reduction in hunger the world has ever seen…The Green Revolution, as this period came to be known in the developing world, has kept more than one billion people from hunger, starvation, and even death…at the core of this development and application of new high-yielding, disease- and insect-resistant seeds, new products to restore soil fertility and control pests, and a succession of agricultural machines to ease the drudgery and speed everything from planting to harvesting…agricultural science is increasingly under attack by groups and individuals who, for *political* rather than scientific reasons, are campaigning to limit advances, especially in new fields such as genetic modification through biotechnology…the debate over biotechnology in the

> **industrialized countries continues to impede its acceptance in most poor, food-insecure countries…New science and biotechnology have the power to address the agro-climatic extremes…Their use lies at the core of extending the Green Revolution to these difficult farming areas."**

Iowans should feel proud at being in the forefront of advances in agricultural sciences. Somewhere this year the 1 Billionth acre of genetically-enhanced seed was planted. A remarkable achievement in 10 years. New applications of agriculture sciences are uncovering new neutraceuticals, improved seed traits and great yield. The world looks to our state to help advance the agricultural biotechnology sciences.

Thank you.

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GM Crops: The Global Economic and Environmental Impact—The First Nine Years 1996–2004

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2005 represents the tenth planting season since genetically modified (GM) crops were first grown in 1996. This milestone provides the opportunity to critically assess the impact this technology is having on global agriculture. This study examines specific global economic impacts on farm income and environmental impacts of the technology with respect to pesticide usage and greenhouse gas emissions for each of the countries where GM crops have been grown since 1996. The analysis shows that there have been substantial net economic benefits at the farm level amounting to a cumulative total of $27 billion. The technology has reduced pesticide spraying by 172 million kg and has reduced the environmental footprint associated with pesticide use by 14%. The technology has also significantly reduced the release of greenhouse gas emissions from agriculture, which is equivalent to removing five million cars from the roads.

Key words: carbon sequestration, cost, environmental impact quotient, GM crops, income, yield.

Introduction

This study presents the findings of research into the global economic and environmental impact of genetically modified (GM) crops since their commercial introduction in 1996. Several studies have investigated the economic and environmental perspectives of GM crops, but these have usually been limited by trait, country, and/or year. This study therefore aims to quantify these impacts cumulatively for the period 1996–2004 through a combination of collating and extrapolating economic analysis findings from past studies and undertaking new environmental impact analysis. This global cumulative analysis over a nine-year period will better identify consistent trends in the technology impact over time as well as identify salient differences in impact between crops, traits, and countries.

The economic impact analysis concentrates on farm income effects, because this is a primary driver of adoption amongst farmers and is an area for which much analysis has been undertaken. The environmental impact analysis focuses on changes in the use of insecticides and herbicides with GM crops and the resulting impact on the environmental load from crop production. Previous investigations have been limited to an examination of changes in pesticide volumes with GM crops, whereas this study expands the analysis and includes a more robust assessment of the specific pesticide products used in different production systems and their environmental load impact. Lastly, we investigate for the first time the contribution of GM crops towards reducing global greenhouse gas (GHG) emissions because of the importance of this issue to the global environment.

Methodology

The report has been compiled based largely on extensive analysis of existing farm-level impact data from GM crops. Primary data for impacts of commercial cultivation were, of course, not available for every crop, in every year, and for each country, but all identified representative previous research has been utilized. The findings of this research have been used as the basis for the analysis presented,[1] although where relevant, primary analysis has been undertaken from base data, most notably in relation to the environmental impacts.

The analysis presented is largely based on the average performance and impact recorded in different crops. The economic performance and environmental footprint of the technology at the farm level does vary widely, both between and within regions and countries. As a result, the impact of this technology, and any new technology, GM or otherwise, is subject to variation at the local level. Therefore, the performance and impact should be considered on a case-by-case basis in terms of crop and trait combinations.

Agricultural production systems are dynamic and vary with time. This analysis seeks to address this issue,

1. *Where several pieces of research of relevance to one subject (e.g., the impact of using a GM trait on the yield of a crop) have been identified, the findings used have been largely based on the average*

wherever possible, by comparing GM production systems with the most likely conventional alternative that could provide competitive levels of efficacy if GM technology had not been available. This approach has been used by other researchers.

Farm Income Effects

Methodology

The primary methodology for assessing the farm-level impact has been to review existing literature from as many years of relevant comparable data as possible and to use the findings as the basis for the impact estimates over the nine-year period examined (Table 1). All values presented are nominal for the year shown, and actual average prices and yields are used for each year. The base currency used is the US dollar, and all financial impacts in other currencies have been converted to US dollars at prevailing annual average exchange rates for each year. The approach reflects changes in farm income in each year arising from yield and price changes and accounts for the possible impact of GM

Table 1. Key baseline assumptions and sources for the farm income impact analysis.

Crop	Country	Yield effect	Cost of technology ($/ha)	Cost savings excluding cost of technology & sources ($/ha)
GM HT soybeans	US	None	$14.82 1996–2002 & $17.3 2003 onwards	$25.2 1996–97 (Marra et al., 2002), $33.9 1998–2000 (Gianessi & Carpenter, 1999), $73.4 2003 (Carpenter & Gianessi, 2001), $78.5 2004 (Sankula & Blumenthal, 2004)
	Argentina	None	$3–4 all years	$24–30; varies each year according to exchange rate (Qaim & Traxler, 2002)
	Brazil	None	As Argentina, except 2004, when $15	$88 in 2004, applied to all other years at prevailing exchange rate
	Paraguay & Uruguay	None	As Argentina	As Argentina; no country-specific analysis identified
	Canada	None	C$32 1997–02, C$48 2003, and C$45 2004[a]	C$47–89 1997–2004[a] (George Morris Center, 2004)
	South Africa	None	R170 each year[a]	R230 each year[a] (Monsanto S. Africa, personal communication, 2005)
	Romania	+31% & 2% price premia from cleaner crops all years	$160 1999 & 2000, $148 2001, $135 2002, $130 2003 all inclusive of 4 litres of Roundup	$140–239 1999–2003 (Brookes, 2003)
GM HT maize	US	None	$14.8 all years	$39.9 all years (Carpenter & Gianessi, 2001; Sankula & Blumenthal, 2004)
	Canada	None	C$27 all years[a]	C$48.75 all years[a] (Monsanto Canada, personal communication, 2005)
	South Africa	None	R80 all years[a]	R107.5 all years[a] (Monsanto S. Africa, personal communication, 2005)
GM HT cotton	US	None	$12.85 1996–2000, $21.32 2001 onwards	$34.12 1996–2000, $66.59 2001 onwards[a] (Carpenter & Gianessi, 2001; Sankula & Blumenthal, 2004)
	Australia	None	AU$50 all years from 2000[a]	AU$60 all years from 2000 (Doyle et al., 2002; Monsanto Australia, personal communication, 2005)
	South Africa	None	R133 all years from 2001[a]	R160 all years from 2001[a] (Monsanto S. Africa, personal communication, 2005)
GM HT canola	US	+6% all years	$29.5 1999–2001, $33 2002 onwards for glyphosate tolerant & $17.3 all years for glufosinate tolerant	$60.75 1999–2001, $67 2002 onwards glyphosate tolerant, $44.89 all years glufosinate tolerant (Carpenter & Gianessi, 2001; Sankula & Blumenthal, 2004)
	Canada	+10.7 all years	C$44.03 all years[a]	C$39 all years[a] (Canola Council, 2001)

Table 1. (continued) Key baseline assumptions and sources for the farm income impact analysis.

Crop	Country	Yield effect	Cost of technology ($/ha)	Cost savings excluding cost of technology & sources ($/ha)
GM IR maize	US	=5% all years	$25 1996 & 1997, $20 1998 & 1999, $22 2000 onwards	$15.5 all years (James, 2002; Carpenter & Gianessi, 2001; Sankula & Blumenthal, 2004; Marra et al., 2002)
	Canada	+5% all years	As US	As US; no specific Canadian studies available but impacts qualitatively confirmed by Monsanto Canada (personal communication, 2005)
	Argentina	+9% all years	As US	Nil all years; no specific Argentine studies identified but values confirmed by Trigo (2005); yield impact based on James (2003)
	Philippines	+25% all years	PS2,800 2003 & 2004[a]	PS800 2003 & 2004[a] (James, various)
	Spain	+6.3% all years	30 euros 1998 & 1999, 28 euros 2000, 18.5 euros 2001 onwards[a]	42 euros all years[a] (Brookes, 2002)
GM IR cotton	US	9% 1996-2002, 11% 2003 & 2004	$58.27 1996–2002, $72.84 2003 & 2004	$63.26 1996–2002, $74.1 2003 & 2004 (Carpenter & Gianessi, 2001; Sankula & Blumenthal, 2004; Marra et al., 2002; Mullins & Hudson, 2004)
	China	+8% 1997-1999, 10% 2000 onwards	$42 all years	$261 2000, $438 2001; average of these used all other years (Pray et al., 2002)
	Australia	None	AU$245 1996 & 1997, AU$155 1998, AU$138 1999–2002, AU$250 2003 & 2004	AU$151 1996, AU$157 1997, AU$188 1998, AU$172 1999, AU$267 2000–2002, AU$347 2003 & 2004[a] (Fitt, 2003; Doyle, 2005; James, 2002)
	Argentina	+30% all years	$86 all years	$17.47 all years (Qaim & De Janvry, 2002, 2005)
	South Africa	24% all years	R376 all years[a]	R127 Rand all years[a] (Ismael et al., 2002; James, 2002; Gouse & Kirsten, 2002)
	Mexico	3%-37% 1996-2004: year specific data used	PS540 1996 and 1999 onwards[a], $65 1997, $56 1998	PS985 pesos 1996 and 1999 onwards[a], $121 1997 and $94 1998 (Traxler et al., 2001; Monsanto Mexico, 2005)
	India	45% 2002, 63% 2003, 54% 2004	Rs2,636 2002, Rs2,512 2003, Rs2,521 2004[a]	Rs2,032 2002, Rs1,767 2003 & Rs1,900 2004[a] (Bennett et al., 2004)
Others	US: GM IR corn rootworm maize	3% 2003 & 2004	$42 both years	$32 both years (Sankula & Blumenthal, 2004)
	US: GM virus resistant papaya	Between 16% and 50% 1999-2004	None 1999–2003, $119 2004	None (Sankula & Blumenthal, 2004)

[a] *Converted to US dollars at prevailing exchange rate.*

crop adoption on global crop supply and world prices. Clearly, this simplistic approach may overstate or understate the real impact of GM technology; the authors acknowledge that this represents a weakness of the research. However, the use of current prices does incorporate some degree of dynamic into the analysis that would otherwise be missing if constant prices had been used. Where yield impacts have been identified in studies for one or a limited number of years, these have been converted into a percentage change impact and applied to all other years on the basis of the prevailing average yield recorded. For example, if a study identified a yield gain of 5% in year one, this 5% yield increase was then applied to the average yield recorded in each other year.[2]

Table 2. Farm-level income impact of using GM HT soybeans in Argentina, 1996–2004.

Year	Cost savings ($/ha)	Net saving on costs (inclusive of cost of technology ($/ha)	GM HT area (million ha)	Increase in farm income at a national level ($ millions)	Value of production ($ million)	Increase in farm income from facilitating additional second cropping ($ millions)
1996	26.10	22.49	0.037	0.90	2,583	0
1997	25.32	21.71	1.756	41.66	2,573	173.8
1998	24.71	21.10	4.80	114.98	3,966	475.2
1999	24.41	20.80	6.64	151.66	3,333	657.4
2000	24.31	20.70	9.00	205.25	4,460	891.0
2001	24.31	20.70	10.93	250.25	5,074	1,081.6
2002	29.00	26.00	12.45	348.90	5,271	1,446.6
2003	29.00	26.00	13.23	386.21	8,618	1,623.6
2004	30.00	27.00	14.06	415.46	7,326	1,701.1

Note. All values for prices and costs denominated in Argentine pesos have been converted to US dollars at the annual average exchange rate in each year.

Example: Farm Income Impact of GM Herbicide-Tolerant Soybeans in Argentina

The analysis of the impact of GM herbicide-tolerant (HT) soybeans in Argentina, summarized in Table 2 and Table 3, is based on data from Qaim and Traxler (2002). The assumed cost of the technology to farmers was $3–4/ha for each year based on the typical seed premiums charged for new seed in 2000 and 2001. This does, however, probably overstate the cost of technology (and understate the farm level cost savings) in subsequent years because of the high proportion (80%) of the Argentine GM soybean crop derived from farm-saved seed on which no seed premium is payable. No positive or negative yield impacts were identified; therefore, all farm income effects are associated with changes in the cost of production. A 0.5% price premium, identified in Qaim and Traxler (2002), has been applied to reflect the impact of the technology on delivering cleaner crops that attract a higher price.

Table 3. Argentina second-crop soybeans.

Year	Second-crop area (million ha)	Increase in income linked to GM HT system (million $)	Additional production (million tonnes)
1996	0.45	Negligible	Negligible
1997	0.65	173.8	0.258
1998	0.8	475.2	0.807
1999	1.4	657.4	2.2
2000	1.6	891.0	2.6
2001	2.4	1,081.6	4.9
2002	2.7	1,446.5	5.8
2003	2.8	1,623.5	6.4
2004	3.0	1,701.1	5.7

Note. Additional gross margin based on $99/ha 1997–2001, 116/ha in 2002, $123/ha in 2003, and $121/ha in 2004 (source: Grupo CEO).

An additional economic impact analyzed was the effect of GM soybeans on the scope for growers planting a second crop of soybeans in the same growing season (usually following on from a wheat crop). The second crop is facilitated substantially by the ease of management of the GM soy crop, which allows farmers to use reduced- or no-tillage systems and hence allows additional time for planting, growing, and harvesting a second crop. The second-cropping benefits presented in Table 3 are based on the gross margin derived from second-crop soybeans multiplied by the total area of second-crop soybeans (less an assumed area of second-crop soybeans that equals the second crop area in 1996).

2. *The average base yield has been adjusted downwards (if necessary) to take account of any positive yield impact of the technology. In this way, the impact on total production of any yield gains is not overstated. The authors do, however, acknowledge that the use of this assumption may still over- or understate the yield effects in some years, because yield impact findings from a limited number of years have been used as the basis for estimating impact in other years. However, in the absence of comprehensive yield impact analysis for each trait, country, and year, the authors consider this an appropriate approach to take in order to estimate cumulative impact.*

Table 4. Global farm income benefits from growing GM crops, 1996–2004 (US$ million).

Trait	2004 increase in farm income	1996–2004 increase in farm income	2004 farm income benefit as % of total value of production of these crops in GM adopting countries	2004 farm income benefit as % of total value of global production of these crops
GM HT soybeans	2,440 (4,141)	9,300 (17,351)	5.6 (9.5)	4.0 (6.7)
GM HT maize	152	579	0.6	Less than 0.5
GM HT cotton	145	750	1.4	0.53
GM HT canola	135	713	8.3	1.34
GM IR maize	415	1,932	1.4	0.8
GM IR cotton	1,472	5,726	10.5	5.3
Others	20	37	N/a	N/a
Totals	4,779 (6,480)	19,037 (27,088)	5.3 (7.2)	3.1 (4.2)

Note. HT = herbicide tolerant, IR =insect resistant, Others = Virus-resistant papaya and squash, rootworm-resistant maize. Figures in parentheses include second-crop benefits in Argentina. Totals for the value shares exclude "other crops" (i.e., relate to the four main crops of soybeans, maize, canola, and cotton).

Results

GM technology has had a very positive impact on farm income derived from a combination of enhanced productivity and efficiency gains (Table 4). In 2004, the direct global farm income benefit from GM crops was $4.8 billion. If the additional income arising from second crop soybeans in Argentina is considered, this income gain rises to $6.5 billion. This is equivalent to adding between 3.1% and 4.2% to the value of global production of the four main crops of soybeans, maize, canola, and cotton—a substantial impact. Since 1996, farm incomes have increased by over $19 billion or $27 billion inclusive of second-crop soybean gains in Argentina.

The largest gains in farm income have arisen in the soybean sector, largely from cost savings, where the $4.14 billion additional income generated by GM HT soybeans in 2004 has been equivalent to adding 9.5% to the value of the crop in the GM-growing countries, or adding the equivalent of 6.7% to the $62 billion value of the global soybean crop. These economic benefits should, however, be placed within the context of a significant increase in the level of soybean production in the main GM-adopting countries. Since 1996, the soybean area and production in the leading soybean-producing countries of the United States, Brazil, and Argentina increased by 56% and 66%, respectively.

Substantial gains have also arisen in the cotton sector through a combination of higher yields and lower costs. In 2004, cotton farm income levels in the GM-adopting countries increased by $1.62 billion, and since 1996, the sector has benefited from an additional $6.5 billion. The 2004 income gains are equivalent to adding nearly 12% to the value of the cotton crop in these countries, or 5.8% to the $28 billion value of total global cotton production. This is a substantial increase in value added terms for two new cotton seed technologies.

Significant increases to farm incomes have also resulted in the maize and canola sectors. The combination of GM insect resistance (IR) and GM HT technology in maize has boosted farm incomes by over $2.5 billion since 1996. In the North American canola sector an additional $713 million has been generated.

Table 5 summarizes farm income impacts in key GM-adopting countries. This highlights the important farm income benefit arising from GM HT soybeans in Argentina, GM IR cotton in China, and a range of GM cultivars in the United States. It also illustrates the growing level of farm income benefits being obtained in developing countries such as South Africa, Paraguay, India, and Mexico.

As well as these quantifiable direct impacts on farm profitability, there have been other important, indirect impacts that are more difficult to quantify (e.g., facilitation of adoption of reduced- or no-tillage systems, reduced production risk, convenience, reduced exposure of farmers and farm workers to pesticides, improved crop quality). These less-tangible benefits have often been cited by GM-adopting farmers as having been important influences for adoption of the technology; therefore, exclusion of these impacts from the analysis in this paper is a limitation of the methodology, although it suggests that the farm income benefits quantified are conservative.

Table 5. GM crop farm income benefits, selected countries, 1996–2004 (US$ million).

	GM HT soybeans	GM HT maize	GM HT cotton	GM HT canola	GM IR maize	GM IR cotton	Total
United States	6,371	564	746	96	1,626	1,301	10,704
Argentina	9,965	n/a	n/a	n/a	120	16	10,101
Brazil	829	n/a	n/a	n/a	n/a	n/a	829
Paraguay	80	n/a	n/a	n/a	n/a	n/a	80
Canada	55	16	n/a	617	119	n/a	807
South Africa	0.8	0.2	0.01	n/a	44	11	56.01
China	n/a	n/a	n/a	n/a	n/a	4,160	4,160
India	n/a	n/a	n/a	n/a	n/a	124	124
Australia	n/a	n/a		n/a	n/a	70	70
Mexico	n/a	n/a	n/a	n/a	n/a	41	41

Note. Argentine GM HT soybeans includes $8,050 billion benefits from second-crop soybeans. N/a = not applicable.

Environmental Impacts from Changes in Insecticide and Herbicide Use

Methodology

The most common way in which changes in pesticide use with GM crops has been presented is in terms of the volume (quantity) of pesticide applied. Although comparisons of total pesticide volume used in GM and non-GM crop production systems can be a useful indicator of environmental impacts, it is an imperfect measure because it does not account for differences in the specific pest control programmes used in GM and non-GM cropping systems. For example, different specific products used in GM versus conventional crop systems, differences in the rate of pesticides used for efficacy, and differences in the environmental characteristics (mobility, persistence, etc.) are masked in general comparisons of total pesticide volumes used.

To provide a more robust measurement of the environmental impact of GM crops, the analysis presented below includes both an assessment of pesticide active ingredient use as well as an assessment of the specific pesticides used via an indicator known as the *environmental impact quotient* (EIQ). This universal indicator, developed by Kovach, Petzoldt, Degni, and Tette (1992) and updated annually, effectively integrates the various environmental impacts of individual pesticides into a single field value per hectare. This provides a more balanced assessment of the impact of GM crops on the environment, as it draws on all of the key toxicity and environmental exposure data related to individual products, as applicable to impacts on farm workers, consumers, and ecology, and provides a consistent and comprehensive measure of environmental impact. Readers should, however, note that the EIQ is an indicator only and therefore does not take into account all environmental issues and impacts.

The EIQ value is multiplied by the amount of pesticide active ingredient (ai) used per hectare to produce a field EIQ value. For example, the EIQ rating for glyphosate is 15.3. By using this rating multiplied by the amount of glyphosate used per hectare (e.g., a hypothetical example of 1.1 kg/ha), the field EIQ value for glyphosate would be equivalent to 16.83/ha.

The EIQ indicator used is therefore a comparison of the field EIQ/ha for conventional versus GM crop production systems, with the total environmental footprint or load of each system, a direct function of respective field EIQ/ha values and the area planted to each type of production (GM versus non-GM). The use of environmental indicators is commonly used by researchers, and the EIQ indicator has been cited by Brimner, Gallivan, and Stephenson (2004) in a study comparing the environmental impacts of GM and non-GM canola.

The EIQ methodology was used to calculate and compare typical EIQ values for conventional and GM crops and then aggregate these values to a national level. The level of pesticide use on the respective areas planted to conventional and GM crops in each year was compared with the level of pesticide use that would otherwise have probably occurred if the whole crop, in each year, had been produced using conventional technology. This is based on the approach used by Sankula and Blumenthal (2004)[3] that identifies and utilizes typical herbicide or insecticide treatment regimes for conventional and GM crops provided by extension and research advi-

3. *Also applied by others (e.g., Kleiter et al., 2005).*

Table 6. Impact of changes in the use of herbicides and insecticides from growing GM crops globally, 1996–2004.

Trait	Change to pesticide use (million kg)	Change in field EIQ (million field EIQ/ha units)	% change in pesticide ai use	% change in EIQ footprint
GM HT soybeans	-41.4	-4,111	-3.8	-19.4
GM HT maize	-18.0	-503	-2.5	-3.4
GM HT cotton	-24.7	-1,002	-14.5	-21.7
GM HT canola	-4.8	-252	-9.7	-20.7
GM IR maize	-6.3	-377	-3.7	-4.4
GM IR cotton	-77.3	-3,463	-14.7	-17.4
Totals	-172.5	-9,708	-6.3	-13.8

sors in each sector or country. This approach was selected to address gaps in the availability of herbicide or insecticide usage data in most countries that differentiates between GM and conventional crops. Additionally, this allows comparisons to be made between GM and non-GM cropping systems when GM accounts for a large proportion of the total crop planted area. For example, in the case of soybeans in several countries, over 60% of the total soybean crop planted area are GM. It is not reasonable to compare the production practices of these two groups, as the remaining nonadopters may be farmers in a region characterized by lower-than-average weed or pest pressures or with a tradition of less-intensive production systems and hence lower-than-average pesticide use.

Results

GM crops have contributed to a significant reduction in the global environmental impact of production agriculture (Table 6). Since 1996, the use of pesticides was reduced by 172 million kg (a 6% reduction), and the overall environmental footprint from GM crops was reduced by 14%. In absolute terms, the largest environmental gain has been associated with the adoption of GM HT soybeans and reflects the large share of global soybean plantings accounted for by GM soybeans. The volume of herbicide use in GM soybeans decreased by 41 million kg since 1996 (a 4% reduction), and the overall environmental footprint decreased by 19%. It should be noted that in some countries, such as in South America, the adoption of GM HT soybeans has coincided with increases in the volume of herbicides used relative to historic levels. This largely reflects the facilitating role of the GM HT technology in accelerating and maintaining the switch away from conventional tillage to no- or low-tillage production systems with their inherent environmental benefits. This net increase in the volume of herbicides used should, therefore, be placed in the context of the reduced GHG emissions arising from this production system change (see below) and the general dynamics of agricultural production system changes.

Major environmental gains have also been derived from the adoption of GM insect resistant (IR) cotton. These gains were the largest of any crop on a per hectare basis. Since 1996, farmers have used 77 million kg less insecticide in GM IR cotton corps (a 15% reduction), and reduced the environmental footprint by 17%. Important environmental gains have also arisen in the maize and canola sectors. In the maize sector, pesticide use decreased by 24 million kg and the environmental footprint decreased by 7.8%, due to a combination of reduced insecticide use and a switch to more environmentally benign herbicides. In the canola sector, farmers reduced herbicide use by 5 million kg (a 10% reduction), and the environmental footprint has fallen by nearly 21% because of a switch to more environmentally benign herbicides. The impact of changes in insecticide and herbicide use at the country level (for the main GM adopting countries) is summarized in Table 7.

Impact on Greenhouse Gas Emissions

Methodology

Reductions in the level of GHG emissions from GM crops derive from two principal sources (Conservation Technology Information Center, 2002; Fabrizzi, Morónc, & García, 2003; Jasa, 2002; Lazarus & Selley, 2005; Reicosky, 1995; Robertson, Paul, & Harwood, 2000; West & Post, 2002). First, GM crops contribute to a reduction in fuel use due to less-frequent herbicide or insecticide applications and a reduction in the energy use in soil cultivation. Lazarus and Selley (2005) reported a reduction of 2.7 kg/ha of carbon dioxide emissions per spray application. In this analysis we used the conservative assumption that only GM IR crops reduced spray applications and ultimately GHG emis-

Table 7. Reduction in environmental footprint from changes in pesticide use associated with GM crop adoption, selected countries, 1996–2004 (% reduction in field EIQ values).

	GM HT soybeans	GM HT maize	GM HT cotton	GM HT canola	GM IR maize	GM IR cotton
United States	28	3	23	32	4.4	20
Argentina	20	n/a	n/a	n/a	0	6.4
Brazil	4	n/a	n/a	n/a	n/a	n/a
Paraguay	10	n/a	n/a	n/a	n/a	n/a
Canada	8	4	n/a	20	NDA	n/a
South Africa	4	0.4	5	n/a	18	NDA
China	n/a	n/a	n/a	n/a	n/a	28
India	n/a	n/a	n/a	n/a	n/a	2.1
Australia	n/a	n/a	3	n/a	n/a	21.2
Mexico	n/a	n/a	n/a	n/a	n/a	NDA

Note. n/a = not applicable; NDA = no data available. Zero impact for GM IR maize in Argentina is due to the negligible (historic) use of insecticides on the Argentine maize crop.

sions. The fuel savings we used resulting from changes in tillage systems are drawn from Carbon Neutral (http://www.carbonneutral.com.au). This source states that the adoption of no-tillage (NT) farming systems reduces cultivation fuel usage by 36.6 litres/ha compared with traditional conventional tillage and 16.7 litres/ha compared with (the average of) chisel plough/disk tillage. In turn, this results in reductions of carbon dioxide emissions of 98.8 kg/ha and 45.0 kg/ha, respectively.

Secondly, the use of no-till and reduced-till[4] farming systems that utilize less plowing increase the amount of organic carbon in the form of crop residue that is stored or sequestered in the soil. This carbon sequestration reduces carbon dioxide emissions to the environment. Rates of carbon sequestration have been calculated for cropping systems using normal tillage and reduced tillage; these were incorporated in our analysis of how GM crops impact on carbon sequestration and ultimately the release of carbon dioxide into the atmosphere. Of course, the amount of carbon sequestered varies by soil type, cropping system, and eco-region. In North America, the International Panel on Climate Change estimates that no-till systems save 300 kg carbon/ha^{-1} yr, reduced-tillage systems save 100 kg carbon/ha^{-1} yr, and conventional tillage systems deliver a loss of 100 kg carbon/ha^{-1} yr. In the analysis presented below, a conservative saving of 100 kg carbon/ha^{-1} yr was applied to all no- and reduced-tillage agriculture to account for the fact that some countries aggregate their no- and reduced-till data. One kg of carbon sequestered is equivalent to 3.67 kg of carbon dioxide. These assumptions were applied to the reduced pesticide spray applications data on GM IR crops derived from the farm income literature review and the GM HT crop areas using no/reduced tillage (limited to the GM HT soybean crops in North and South America and GM HT canola crop in Canada[5]).

Table 8 summarizes the impact on GHG emissions associated with the planting of GM crops between 1996 and 2004. In 2004, the permanent carbon dioxide savings from reduced fuel use associated with GM crops was 1 billion kg. This is equivalent to removing 480,000 cars from the road for a year.

The additional soil carbon sequestration gains resulting from reduced tillage with GM crops accounted for a reduction in 9.4 billion kg of carbon dioxide emissions in 2004. This is equivalent to removing nearly 4.7 million cars from the roads for a year (equal to 19% of all registered cars in the UK).

Concluding Comments

This study quantified the cumulative global impact of GM technology between 1996 and 2004 on farm income, pesticide usage, and greenhouse gas emissions.

4. *No-till farming means that the ground is not plowed at all, and reduced tillage means that the ground is disturbed less than it would be with traditional tillage systems. For example, under a no-till farming system, soybean seeds are planted through the organic material that is left over from a previous crop such as corn, cotton, or wheat.*

5. *Due to the likely small-scale impact and/or lack of tillage-specific data relating to GM HT maize and cotton crops (and the US GM HT canola crop), analysis of possible GHG emission reductions in these crops have not been included in this analysis*

Table 8. Impact of GM crops on carbon sequestration impact in 2004 (car equivalents).

Crop/trait/country	Carbon dioxide savings arising from reduced fuel use (million kg of carbon dioxide)	Carbon dioxide savings from reduced fuel use in family car equivalents removed from the road for a year	Carbon dioxide savings from soil carbon sequestration (million kg of carbon dioxide)	Carbon dioxide savings from soil carbon sequestration in family car equivalents removed from the road for a year
US: GM HT soybeans	322	142,889	3,762	1,672,178
Argentina: GM HT soybeans	532	236,444	4,186	1,860,400
Other countries: GM HT soybeans	73	32,444	569	252,889
Canada: GM HT canola	94	41,778	906	402,800
Global GM IR cotton	61	27,111	0	0
Total	1,082	480,666	9,423	4,188,267

Note. Data assumes that an average family car produces 150 grams of carbon dioxide per km. A car does an average of 15,000 km/year and therefore produces 2,250 kg of carbon dioxide/year.

The analysis shows that there have been substantial economic benefits at the farm level, amounting to a cumulative total of $27 billion. GM technology has also resulted in 172 million kg less pesticide use by growers and a 14% reduction in the environmental footprint associated with pesticide use. GM crops have also made a significant contribution to reducing greenhouse gas emissions by over 10 billion kg, equivalent to removing five million cars from the roads for a year.

The impacts identified are, however, probably conservative, reflecting the limitations of the methodologies used to estimate each of the three main categories of impact and the limited availability of relevant data. As such, subsequent research might usefully extend the analysis to incorporate more sophisticated consideration of dynamic economic impacts and some of the less-tangible economic impacts (e.g., on labor savings). Further analysis of the environmental impact might also usefully include additional environmental indicators such as impact on soil erosion.

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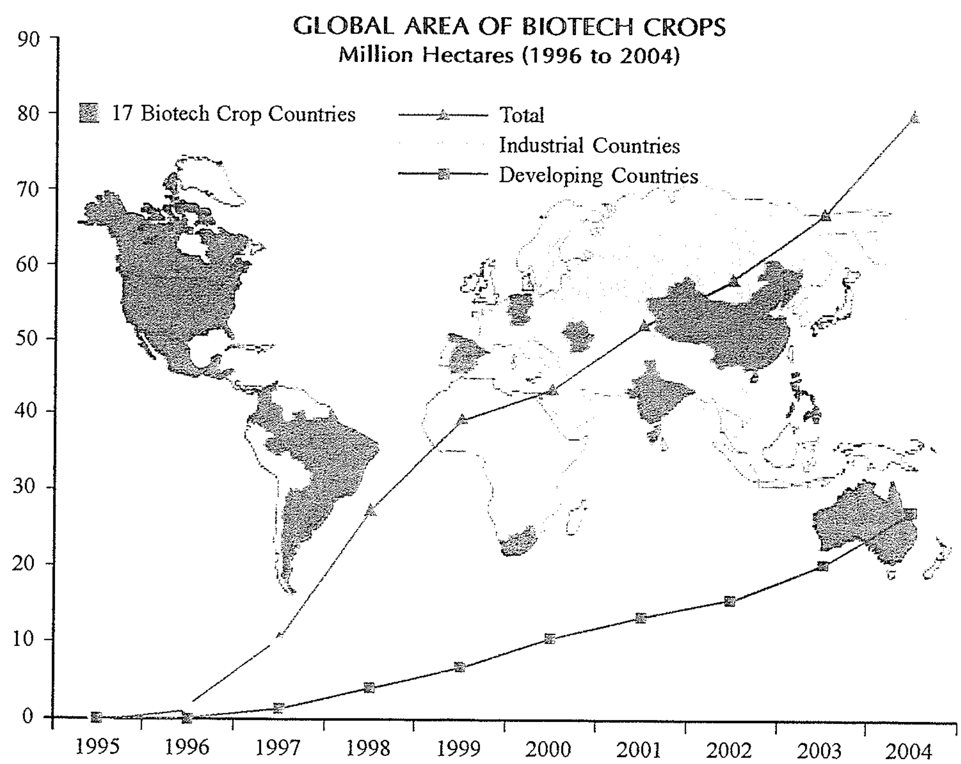
EXECUTIVE SUMMARY

PREVIEW

Global Status of Commercialized Biotech/GM Crops: 2004

by

Clive James
Chair, ISAAA Board of Directors



Increase of 20%, 13.3 million hectares or 32.9 million acres between 2003 and 2004.

Source: Clive James, 2004

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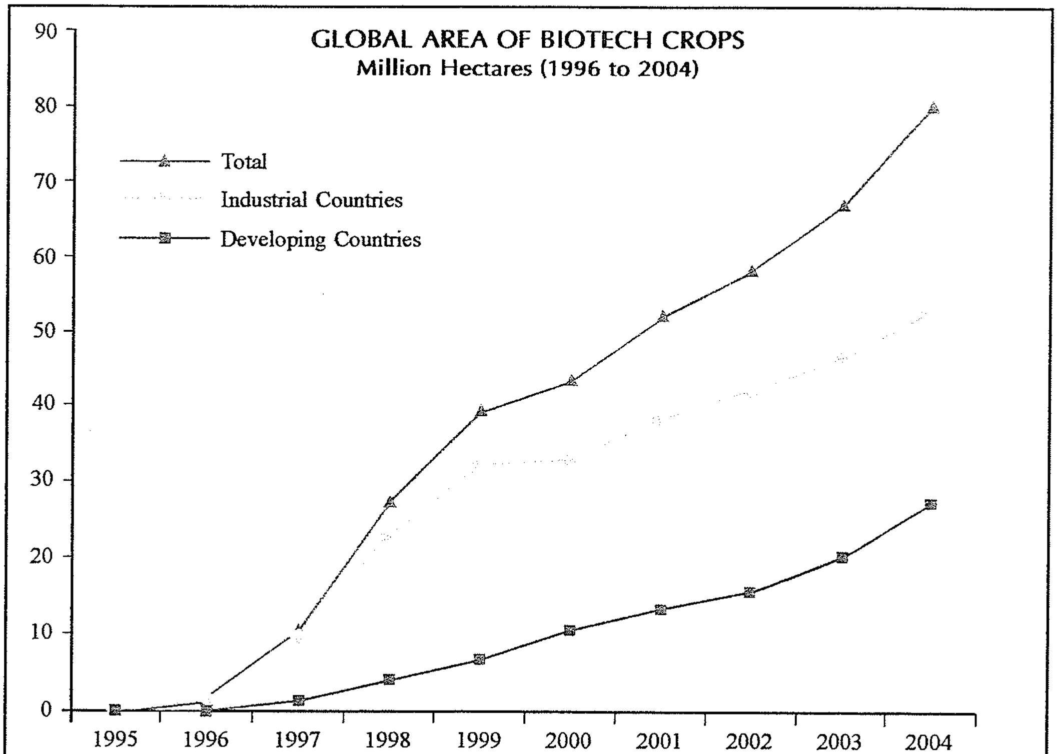
GLOBAL STATUS OF COMMERCIALIZED BIOTECH/GM CROPS: 2004

Global Status of Biotech Crops in 2004

- 2004 is the penultimate year of the first decade of the commercialization of genetically modified (GM) or transgenic crops, now often called biotech crops, as referred to consistently in this Brief. In 2004, the global area of biotech crops continued to grow for the ninth consecutive year at a sustained double-digit growth rate of 20%, compared with 15% in 2003. The estimated global area of approved biotech crops for 2004 was 81.0 million hectares, equivalent to 200 million acres, up from 67.7 million hectares or 167 million acres in 2003. Biotech crops were grown by approximately 8.25 million farmers in 17 countries in 2004, up from 7 million farmers in 18 countries in 2003. Notably, 90% of the beneficiary farmers were resource-poor farmers from developing countries, whose increased incomes from biotech crops contributed to the alleviation of poverty. The increase in biotech crop area between 2003 and 2004, of 13.3 million hectares or 32.9 million acres, is the second highest on record. In 2004, there were fourteen biotech mega-countries (compared with ten in 2003), growing 50,000 hectares or more, 9 developing countries and 5 industrial countries; they were, in order of hectarage, USA, Argentina, Canada, Brazil, China, Paraguay, India, South Africa, Uruguay, Australia, Romania, Mexico, Spain and the Philippines. During the period 1996-2004, the accumulated global biotech crop area was 385 million hectares or 951 million acres, equivalent to 40% of the total land area of the USA or China, or 15 times the total land area of the UK. The continuing rapid adoption of biotech crops reflects the substantial improvements in productivity, the environment, economics, health and social benefits realized by both large and small farmers, consumers and society in both industrial and developing countries.



Increase of 20%, 13.3 million hectares or 32.9 million acres between 2003 and 2004.

Source: Clive James, 2004

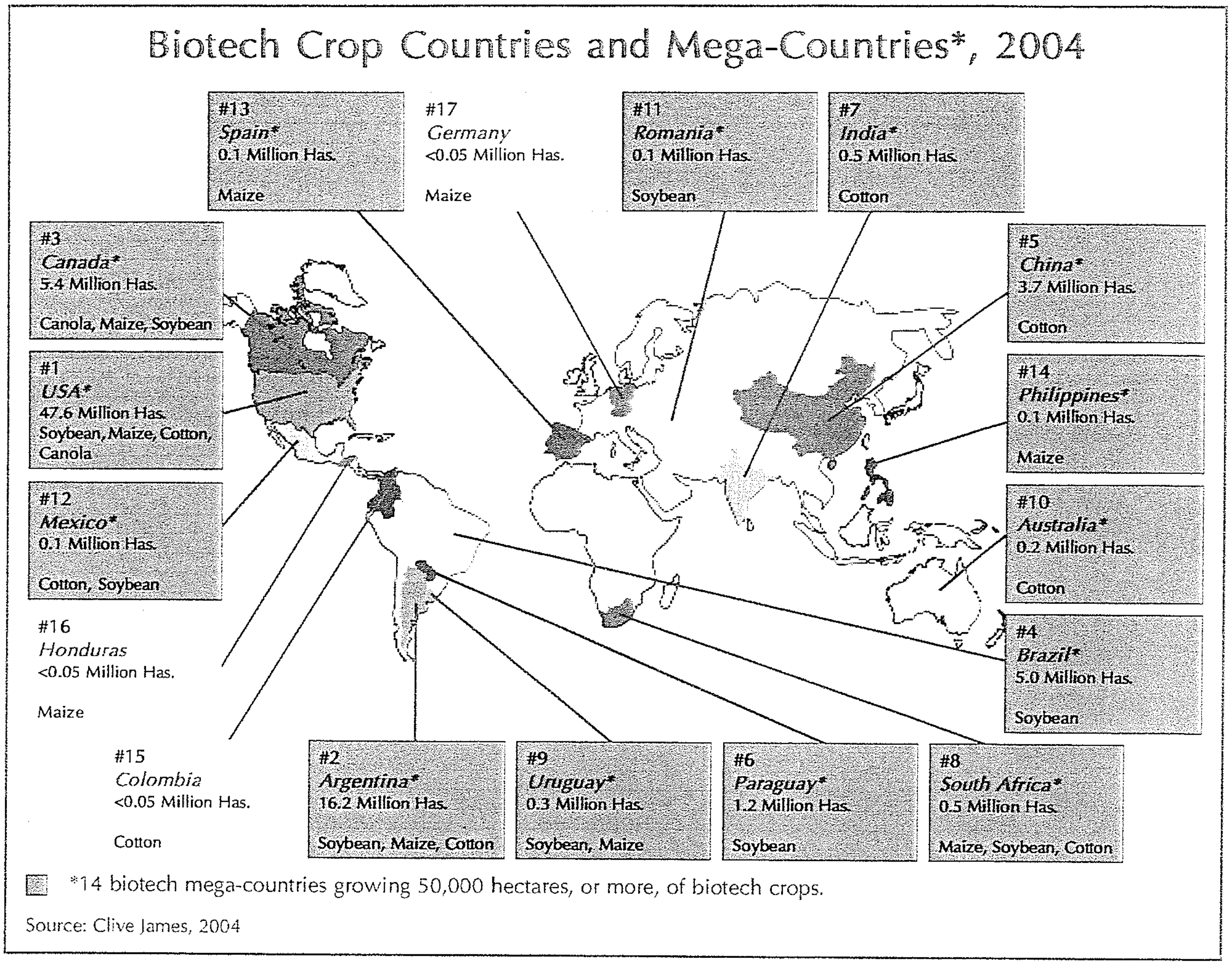
- During the nine-year period 1996 to 2004, global area of biotech crops increased more than 47 fold, from 1.7 million hectares in 1996 to 81.0 million hectares in 2004, with an increasing proportion grown by developing countries. More than one-third (34%) of the global biotech crop area of 81 million hectares in 2004, equivalent to 27.6 million hectares, was grown in developing countries where growth continued to be strong. It is noteworthy that the absolute growth in biotech crop area between 2003 and 2004 was, for the first time, higher for developing countries (7.2 million hectares) than for industrial countries (6.1 million hectares), with the percentage growth almost three times as high (35%) in the developing countries of the South, compared with the industrial countries of the North (13%). The increased hectarage and impact of the five principal developing countries* (China, India, Argentina, Brazil and South Africa) growing biotech crops is an important trend with implications for the future adoption and acceptance of biotech crops worldwide; see full Brief for biotech crop overviews for each of the five countries. In 2004, the number of developing countries growing biotech crops (11) was almost double the number of industrial countries (6) adopting biotech crops.

Biotech Crop Area by Country, Crop and Trait

- Countries that grow 50,000 hectares, or more, of biotech crops are classified as biotech mega-countries. In 2004, there were 14 mega-countries, compared with 10 in 2003, with Paraguay, Spain, Mexico and the Philippines joining the mega- country group for the first time in 2004. This 40% increase in the number of mega-countries reflects a more balanced and stabilized participation of a broader group of countries adopting biotech crops. The 14 mega-countries, in descending order of hectarage of biotech crops, were: USA with 47.6 million hectares (59% of global total), followed by Argentina with 16.2 million hectares (20%), Canada 5.4 million hectares (6%), Brazil 5.0 million hectares (6%), China 3.7 million hectares (5%), Paraguay with 1.2 million hectares (2%) reporting biotech crops for the first time in 2004, India 0.5 million hectares ((1%), South Africa 0.5 million hectares (1%), Uruguay 0.3 million hectares (<1%), Australia 0.2 million hectares (<1%), Romania 0.1 million hectares (<1%), Mexico 0.1 million hectares (<1%), Spain 0.1 million hectares (<1%), and the Philippines 0.1 million hectares (<1%).

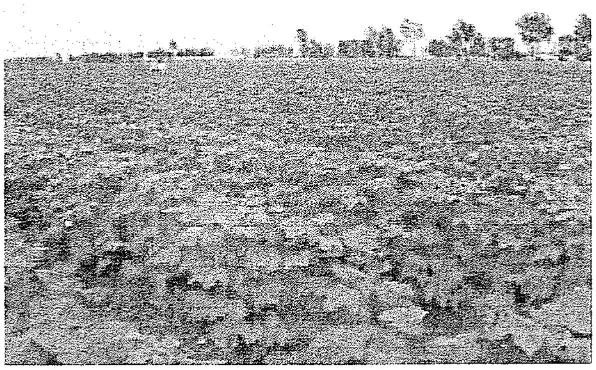
- Based on annual percentage growth in area, of the eight leading biotech crop countries, India had the highest percentage year-on-year growth in 2004 with an increase of 400% in Bt cotton area over 2003, followed by Uruguay (200%), Australia (100%), Brazil (66%), China (32%), South Africa (25%), Canada (23%) Argentina (17%) and the USA at 11%. In 2004, India increased its area of approved Bt cotton, introduced only two years ago, from approximately 100,000 hectares in 2003 to 500,000 hectares in 2004 when approximately 300,000 small farmers

** Highlighted in this Executive Summary in 5 boxes with photos*



benefited from Bt cotton. Whereas growth in Uruguay in 2004 was accentuated by a conservative 2003 adoption rate, biotech soybean now occupies >99 % of the total soybean area in Uruguay, plus a significant increase in biotech maize taking the total biotech crop area above 300,000 hectares. After suffering severe drought for the last two years, Australia increased its total cotton plantings to about 310,000 hectares of which 80%, equivalent to 250,000 hectares, were planted with biotech cotton in 2004. Brazil increased its biotech soybean area by two-thirds from 3 million hectares in 2003 to a projected conservative 5 million hectares in 2004, with another significant increase likely in 2005. China increased its Bt cotton area for the seventh consecutive year; an increase of one-third from 2.8 million hectares in 2003 to 3.7 million hectares in 2004, equivalent to 66% of the total cotton area of 5.6 million hectares in 2004, the largest national cotton hectarage planted in China since the introduction of Bt cotton in 1997. South Africa reported a 25% increase in its combined area of biotech maize, soybean and cotton to

CHINA Biotech Cotton



Population : 1,300m (1.3 billion)
% employed in agriculture : 50%
Agriculture as % of GDP : 15%
Area under biotech crops : 3.7 million hectares

Crop	National Hectarage '000 ha	Biotech Hectarage '000 ha	Biotech % of Total Area Planted
Cotton	5,600	3,700	66

0.5 million hectares in 2004; growth continued in both white maize used for food, and yellow maize used for feed, as well as strong growth in biotech soybean, up from 35% adoption in 2003 to 50% in 2004, whilst Bt cotton has stabilized at about 85% adoption. Canada increased its combined area of biotech canola, maize and soybean by 23% with a total of 5.4 million hectares with 77% of its canola hectarage planted to biotech varieties. The adoption of herbicide tolerant soybeans in Argentina, which was close to 100% in 2003, continued to climb in 2004 as total plantings of soybean increased, which along with biotech maize and cotton reached an all time high of 16.2 million hectares of biotech crops. In the USA, there was an estimated net gain of 11% of biotech crops in 2004, as a result of significant increases in the area of biotech maize, followed by biotech soybean, with modest growth in biotech cotton which started to peak in the USA in 2004 as adoption approached 80%. In 2004, for the first time, Paraguay reported 1.2 million hectares of biotech soybean, equivalent to 60% of its national soybean hectarage of 2 million hectares. Spain, the only EU country to grow a significant hectarage of a commercial biotech crop, increased its Bt maize area by over 80% from 32,000 hectares in 2003 to 58,000 hectares in 2004, equivalent to 12% of the national maize crop. In Eastern Europe, Romania, which is a biotech mega-country, growing more than 50,000 hectares of biotech soybean, also reported significant growth. Bulgaria and Indonesia did not report biotech maize and cotton, respectively in 2004 due to expiry of permits. Two countries, Mexico and the Philippines which attained the status of biotech mega-countries for the first time in 2004 reported 75,000 hectares and 52,000 hectares of biotech crops, respectively for 2004. Other countries that have only recently introduced biotech crops, such as Colombia and Honduras reported modest growth, whilst Germany planted a token hectarage of Bt maize.

- Globally, in 2004, growth continued in all four commercialized biotech crops. Biotech soybean occupied 48.4 million hectares (60% of global biotech area), up from 41.4 million hectares in 2003. Biotech maize was planted on 19.3 million hectares (23% of global biotech crop area), up substantially from 15.5 million hectares in 2003, co-sharing the highest growth rate with cotton at 25% - this follows a 25% growth rate in biotech maize in 2003 and 27% in 2002. Biotech maize is projected to have the highest percentage growth rate for the near term as maize demand increases and as more beneficial traits become available and approved. Biotech cotton was grown on 9.0 million hectares (11% of global biotech area) compared with 7.2 million hectares in 2003. Bt cotton is expected to continue to grow in 2005 and beyond, as India and China continue to increase their hectarage and new countries introduce the crop for the first time. Biotech canola occupied 4.3 million hectares (6% of global biotech area), up from 3.6 million hectares in 2003. In 2004, 5% of the 1.5 billion hectares of all global cultivable crop land was occupied by biotech crops.

INDIA Biotech Cotton

PABLO BARTHOLOMEW

Population	: 1,000m (1 billion)
% employed in agriculture	: 67%
Agriculture as % of GDP	: 23%
Area under biotech crops	: 500,000 hectares

Crop	National Hectarage '000 ha	Biotech Hectarage '000 ha	Biotech % of Total Area Planted
Cotton	9,000	500	6

- During the nine-year period 1996 to 2004, herbicide tolerance has consistently been the dominant trait followed by insect resistance. In 2004, herbicide tolerance, deployed in soybean, maize, canola and cotton occupied 72% or 58.6 million hectares of the global biotech 81.0 million hectares, with 15.6 million hectares (19%) planted to Bt crops. Stacked genes for herbicide tolerance and insect resistance, deployed in both cotton and maize continued to grow, occupying 9% or 6.8 million hectares, up from 5.8 million hectares in 2004. The two dominant biotech crop/trait combinations in 2004 were: herbicide tolerant soybean occupying 48.4 million hectares or 60% of the global biotech area and grown in nine countries; and Bt maize, occupying 11.2 million hectares, equivalent to 14% of global biotech area and also grown in nine countries. Whereas the largest increase in Bt maize was in the USA, growth was witnessed in all other eight countries growing Bt maize. Notably, South Africa grew 155,000 hectares of Bt white maize for food in 2004, a substantial 25 fold increase from when it was first introduced in 2001. Bt/herbicide tolerant maize and cotton both increased substantially, reflecting a continuing trend for stacked genes to occupy an increasing area planted to biotech crops on a global basis.

- Another way to provide a global perspective of the adoption of biotech crops is to express the global adoption rates for the four principal biotech crops as a percentage of their respective global areas. In 2004, 56% of the 86 million hectares of soybean planted globally were biotech - up from 55% in 2003. Twenty-eight percent of the 32 million hectares of cotton were biotech crops, up from 21% last year. The area planted to biotech canola in 2004 was 19% of 23 million hectares, up from 16% in 2003. Finally, of the 140 million hectares of maize grown globally, 14% was biotech in 2004 equivalent to 19.3 million hectares, up from 11% or 15.5 million hectares in 2003. If the global areas (conventional and biotech) of these four principal biotech crops are aggregated, the total area is 284 million hectares of which 29% was biotech in 2004, up from 25% in 2003. Thus, close to 30% of the aggregate area of the four crops, totaling over one quarter billion hectares is now biotech. The biggest increase in 2004 was a 7.0 million hectares increase in biotech soybean equivalent to a 17% year-on-year growth, followed by a 3.8 million hectare increase in biotech maize equivalent to a substantial 25% year-on-year growth, which follows a 25% year-on-year growth in 2003.

The Global Value of the Biotech Crop Market

- In 2004, the global market value of biotech crops, forecasted by Cropnosis, was $4.70 billion representing 15% of the $32.5 billion global crop protection market in 2003 and 16% of the $30 billion global commercial seed market. The market value of the global biotech crop market is based on the sale price of biotech seed plus any technology fees that apply. The accumulated global value for the nine year period 1996 to 2004, since biotech crops were first commercialized in 1996, is $24 billion. The global value of the biotech crop market is projected at more than $5 billion for 2005.

Benefits from Biotech Crops

- The experience of the first nine years, 1996 to 2004, during which a cumulative total of over 385 million hectares (951 million acres, equivalent to 40% of the total land area of the USA or China) of biotech crops were planted globally in 22 countries, has met the expectations of millions of large and small farmers in both industrial and developing countries. Biotech crops are also delivering benefits to consumers and society at large, through more affordable food, feed and fiber that require less pesticides and hence a more sustainable environment. The global value of total crop production from biotech crops in 2003 was estimated at $44 billion. Net economic benefits to producers from biotech crops in the USA in 2003 were estimated at $1.9 billion whilst gains in Argentina for the 2001/02 season were $1.7 billion. China has projected potential gains of $5 billion in 2010, $1 billion from Bt cotton and $4

ARGENTINA Biotech Soybean

POPULATION:
38m

% EMPLOYED IN AGRICULTURE
1%

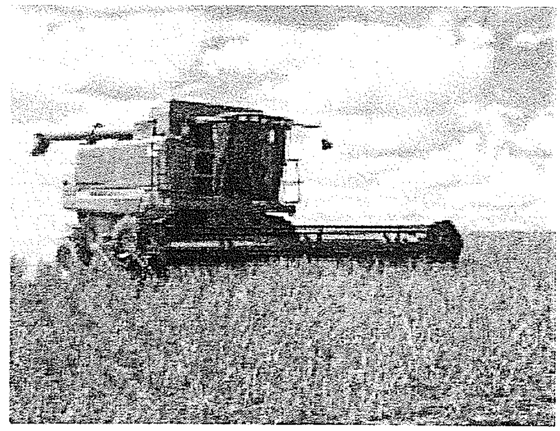
AGRICULTURE AS % OF GDP
11%

AREA UNDER BIOTECH CROPS
16.2 million hectares

Crop	National Hectarage '000 ha	Biotech Hectarage '000 ha	Biotech % of Total Area Planted
Soybean	14,750	14,500	98
Maize	3,000	1,700	55
Cotton	100-125 ha	25	20-25%

billion from Bt rice, expected to be approved in the near term. A global study by Australian economists, on biotech grains, oil seeds, fruit and vegetables, projects a global potential gain of $210 billion by 2015; the projection is based on full adoption with 10% productivity gains in high and middle income countries, and 20% in low income countries. The 2004 data are consistent with previous experience confirming that commercialized biotech crops continue to deliver significant economic, environmental, health and social benefits to both small and large farmers in developing and industrial countries. The number of farmers benefiting from biotech crops continued to grow to reach 8.25 million in 2004, up from 7 million in 2003. Notably, 90% of these 8.25 million farmers benefiting from biotech crops in 2004, were resource-poor farmers planting Bt cotton, whose increased incomes have contributed to the alleviation of poverty. These included 7 million resource-poor farmers in all the cotton growing provinces of China, an estimated 300,000 small farmers in India, and subsistence farmers in the Makhathini Flats in KwaZulu Natal province in South Africa, and in the other eight developing countries where biotech crops were planted in 2004.

BRAZIL Biotech Soybean



Population : 175m
% employed in agriculture : 21%
Agriculture as % of GDP : 9%
Area under biotech crops : 5 million hectares

Crop	National Hectarage '000 ha	Biotech Hectarage '000 ha	Biotech % of Total Area Planted
Soybean	23,000	5,000	22

Future Prospects

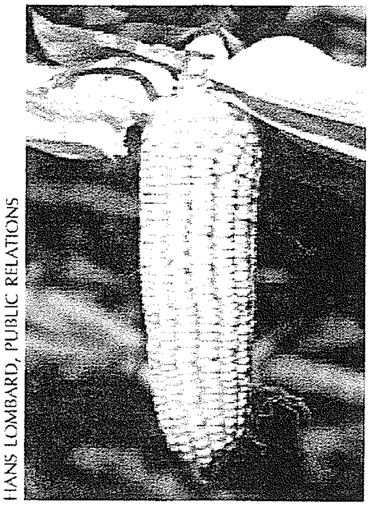
- 2004 is the penultimate year of the first decade of the commercialization of biotech crops during which double-digit growth in global hectarage of biotech crops has been achieved every single year; this is an unwavering and resolute vote of confidence in the technology from the 25 million farmers, who are masters in risk aversion, and have consistently chosen to plant an increasing hectarage of biotech crops year, after year, after year. The 10th anniversary in 2005, will be a just cause for celebration worldwide by farmers, the international scientific and development community, global society, and the peoples in developing and industrial countries on all six continents that have benefited significantly from the technology, particularly the humanitarian contribution to the alleviation of poverty, malnutrition and hunger in the countries of Asia, Africa and Latin America. On a global basis, there is cause for cautious optimism with the global area and the number of farmers planting biotech crops expected to continue to grow in 2005 and beyond. In the established industrial country markets of the USA and Canada, growth will continue with the introduction of new traits; for example, the significant biotech hectarage planted in 2004 in North America to MON 863 for corn rootworm control (approximately 700,000 hectares of the single/stacked product) and TC 1507 for broader lepidopteran control (approximately 1.2 million hectares). The global number and proportion of small farmers from developing countries growing biotech crops is expected to increase significantly to meet their food/feed crop requirements and meat demands of their burgeoning and more affluent populations. A similar trend may also apply to the poorer and more agriculturally based countries of Eastern Europe which have recently joined the EU, and those expected to join in 2007 and beyond. Finally, there were signs of progress in the European Union in 2004 with the EU Commission approving, for import, two events in biotech maize (Bt11 and NK603) for food and feed use, thus signaling the end of the 1998 moratorium. The Commission also approved 17 maize varieties, with insect resistance conferred by MON 810, making it the first biotech crop to be approved for planting in all 25 EU countries. The use of MON 810 maize, in conjunction with practical and equitable co-existence policies, opens up new opportunities for EU member countries to benefit from the commercialization of biotech maize, which Spain has successfully deployed since 1998. Taking all factors into account, the outlook for 2010 points to continued growth in the global hectarage of biotech crops, up to 150 million hectares, with up to 15 million farmers growing crops in up to 30 countries.

The Potential Impact of the Lead Developing Countries on Global Acceptance of Biotech Crops

- Of the 11 developing countries that have already approved and adopted biotech crops to meet their own food, feed and fiber needs and/or to optimize exports, there are five lead countries that will exert leadership and have a significant impact on future adoption and acceptance of biotech crops globally, because of their significant role in biotech crops and generally in world affairs. These five countries are China and India in Asia, Brazil and Argentina in Latin America, and South Africa on the continent of Africa. Collectively, they planted approximately 26 million hectares of biotech crops in 2004, (equivalent to approximately one-third of global biotech hectarage) to meet the needs of their combined populations of 2.6 billion (approximately 40% of global population) which generated an aggregated agricultural GDP of almost $370 billion and provided a livelihood for 1.3 billion of their people. Of the five principal biotech developing countries, China is likely to be the most influential, and what China is to Asia, Brazil is to Latin America, and South Africa is to the continent of Africa. There is little doubt that China intends to be one of the world leaders in biotechnology since Chinese policymakers have concluded that there are unacceptable risks of being dependent on imported technologies for food, feed and fiber security.

- The sharing of the significant body of knowledge and experience that has been accumulated on biotech crops in developing countries, since their commercialization in 1996, is an essential ingredient for a transparent, and knowledge-based discussion by an informed global society about the potential humanitarian and material benefits that biotech crops offer developing countries. The five lead biotech crop countries from the South, China, India, Argentina, Brazil and South Africa, offer a unique experience from developing countries in all three continents of the South – Asia, Latin America and Africa. The collective experience and voice of these five key countries represent a coalition of influential opinion from the South re biotech crops that will also influence acceptance of biotech crops globally. In the near term, the one single event that is likely to have the greatest impact is the approval and adoption of Bt rice in China, which is considered to be likely in the near term, probably in 2005. The adoption of biotech rice by China, not only involves the most important food crop in the world but the culture of Asia. It will provide the stimulus that will have a major impact on the acceptance of biotech rice in Asia and, more generally, on the acceptance of biotech food, feed and fiber crops worldwide. Adoption of biotech rice will contribute to a global momentum that will herald a new chapter in the debate on the acceptance of biotech crops which will be increasingly influenced by countries in the South, where the new technology can contribute the biggest benefits and where the humanitarian needs are greatest – a contribution to the alleviation of malnutrition, hunger and poverty. Global society has pledged to reduce poverty by half by 2015, and if it is to maintain credibility, it must practice what it preaches and deliver what it promises. Reducing poverty by half by 2015 is an imperative moral obligation and is one of the most formidable challenges facing the world today, to which biotech crops can make a vital contribution. It is appropriate that it is the countries of the South, led by China, India, Argentina, Brazil and South Africa, which are exerting increasing leadership in the adoption of biotech crops and have the courage to address issues that will determine their own survival and destiny, at a time when some segments of global society are still engaged in an ongoing debate on biotech crops that has resulted in paralysis through over-analysis.

SOUTH AFRICA Biotech Maize



HANS LOMBARD, PUBLIC RELATIONS

POPULATION:
44m

% EMPLOYED IN AGRICULTURE:
11%

AGRICULTURE AS % OF GDP:
4%

AREA UNDER BIOTECH CROPS:
500,000 hectares

Crop	National Hectarage '000 ha	Biotech Hectarage '000 ha	Biotech % of Total Area Planted
Maize	2,600	400	15
Soybean	140	70	50%
Cotton	35-40	30	85%

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APPLICATIONS

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National Center For
Food And Agricultural Policy

National Center For
Food And Agricultural Policy

Jill Long Thompson
Chief Executive Officer and Senior Fellow
National Center for Food and Agricultural Policy

Jill Long Thompson became the chief executive officer of the National Center for Food and Agricultural Policy in August 2003. Prior to joining the National Center for Food and Agricultural Policy, Thompson served as under secretary of agriculture for rural development in the United States Department of Agriculture.

Before serving in the USDA, Thompson represented Indiana's fourth district in the U.S. House of Representatives. During her tenure, she served on the Select Committee on Hunger and the House Agricultural Committee. Both of these appointments increased her understanding of the international and domestic issues facing the agricultural industry and the role agricultural advancement plays in feeding the hungry worldwide.

After leaving Congress, Thompson conducted a study group on agriculture and rural policy as a fellow at Harvard University's Kennedy School of Government.

She graduated with a Ph.D. from Indiana University's School of Business and resides with her husband on their family farm in Marshall County, Ind.

Sujatha Sankula
Director of Biotechnology Research
National Center for Food and Agricultural Policy

Sujatha Sankula, who joined the National Center for Food and Agricultural Policy in 2001, conducts research on the impacts and regulation of biotechnology-derived crops, as well as pest management issues in U.S. crops. Prior to joining the National Center for Food and Agricultural Policy, she held research positions in the plant and soil science departments at the University of Delaware and Louisiana State University where she studied biotechnology, weed management and crop production practices.

Sankula's research has been published extensively in scientific journals, books and proceedings. Her recent research analyzed comparative environmental impacts of conventional and biotechnology-derived crops. She also conducted a six-year sustainable agricultural study that compared weed management techniques, yield and economic returns in different production systems.

As a recognized authority on biotechnology, Sankula has briefed the Environmental Protection Agency, U.S. House of Representatives Committee on Science and the U.S. Senate and House Agriculture Committees on the comparative environmental impacts of crops developed through biotechnology methods. In addition, at the request of the U.S. Foreign Agricultural Service, she has addressed biotechnology to the European press. She also has briefed Mexican opinion leaders and delegates of the U.S. State Department International Visitor Program.

Sankula holds a Ph.D. in Weed Science from the Department of Plant Pathology and Crop Physiology at Louisiana State University.

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National Center For
Food And Agricultural Policy

COMMODITY BY COMMODITY ANALYSIS
Impacts on U.S. Agriculture of Biotechnology-Derived Crops Planted in 2003: An Update of 11 Case Studies

The following crops evaluated in the study currently have approved varieties developed through biotechnology methods in production. The study indicates that* Bt *corn varieties have had the greatest effect on yields, increasing food production by 4.9 billion pounds, while herbicide-tolerant soybean varieties have created the biggest pesticide reduction, eliminating the use of 20 million pounds of pesticide annually. Herbicide-tolerant soybeans had the greatest impact on farmers' pocketbook, improving farm income by nearly $1.2 billion.

Canola (HT) — The study covered canola grown in North Dakota, which represents about 75 percent of the nation's total canola production. Herbicide-tolerant varieties reduced herbicide use by more than 154,000 pounds per year and saved farmers $9 million on weed management costs.

Cotton (HT) — The study included cotton grown in Alabama, Arizona, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, Missouri, New Mexico, North Carolina, Oklahoma, South Carolina, Tennessee, Texas and Virginia. These states produce more than 99 percent of U.S. upland cotton. Herbicide-tolerant cotton varieties reduced herbicide use by more than 9.6 million pounds, saving cotton farmers more than $221 million per year in weed control costs.

Cotton (IR-I) — The study included cotton grown in Alabama, Arizona, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, Missouri, New Mexico, North Carolina, Oklahoma, South Carolina, Tennessee, Texas and Virginia. These states produce more than 99 percent of U.S. upland cotton. *Bt* varieties with resistance to tobacco budworm and pink bollworm increased production by more than 362 million pounds, improved farm income by nearly $191 million and reduced pesticide use by more than 3.2 million pounds.

Cotton (IR-II) — The study included cotton grown in Alabama, Arizona, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, Missouri, New Mexico, North Carolina, Oklahoma, South Carolina, Tennessee, Texas and Virginia. These states produce more than 99 percent of U.S. upland cotton. Varieties with enhanced protection against cotton bollworm, beet armyworms, fall armyworms and soybean loopers, while maintaining protection against tobacco budworm and pink bollworm, have increased production by more than 2.3 million pounds, improved farm income by $1.2 million and reduced pesticide use by more than more than 38,000 pounds.

HT = herbicide tolerant
IR = insecticide resistant
VR = virus resistant

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Field Corn (IR-I) — The study covered corn grown in 36 states, including Alabama, Arkansas, Arizona, Colorado, Connecticut, Delaware, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Massachusetts, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, Vermont, West Virginia and Wisconsin. These states represent 99 percent of U.S. corn production. *Bt* varieties with resistance to European corn borer have increased production by more than 4.7 billion pounds, improved farm income by more than $146 million and reduced insecticide use by more than 3.6 million pounds annually.

Field Corn (IR-II) — The study covered corn grown in 12 states, including Colorado, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, South Dakota and Wisconsin. These states represent 88 percent of U.S. corn production. New varieties with resistance to corn rootworm and planted acreage of less than 1 percent have improved farm income by $2.4 million and reduced insecticide use by more than 224,000 pounds annually.

Field Corn (IR-III) — The study covered corn grown in 24 states, including Colorado, Delaware, Illinois, Indiana, Iowa, Kansas, Maryland, Michigan, Minnesota, Missouri, Nebraska, New Jersey, New Mexico, New York, North Dakota, Ohio, Oklahoma, Pennsylvania, South Dakota, Texas, Virginia, Wisconsin, West Virginia and Wyoming. These states represent 94 percent of U.S. corn production. New varieties with resistance to black cutworm, corn borers, corn earworm and fall armyworm have increased production by 163 million pounds, boosted farm income by $9.7 million and reduced pesticide use by more than 40,000 pounds annually.

Papaya (VR) — The study covered papaya production in Hawaii, the only U.S. state that commercially produces the fruit. Varieties with resistance to the devastating papaya ring spot virus have increased production by nearly 9 million pounds and increased farm income by $2.9 million annually.

Soybean (HT) — The study covered soybeans grown in 31 states, including Alabama, Arkansas, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, West Virginia and Wisconsin. These states represent 100 percent of U.S. soybean production. Herbicide-tolerant varieties have improved farm income by more than $1.1 billion and reduced insecticide use by more than 20 million pounds annually.

Squash (VR) — The study covered squash grown in Florida and Georgia, which represents 31 percent of U.S. fresh market squash. Varieties with resistance to four different mosaic viruses increased production in the states by 24 million pounds a year, increasing income for Florida and Georgia growers by $6.56 million.

HT = herbicide tolerant
IR = insecticide resistant
VR = virus resistant

Impacts on U.S. Agriculture of Biotechnology-Derived Crops Planted in 2003

An Update of 11 Case Studies

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(For full report, see www.ncfap.org)

KEY FINDINGS

Crops developed through biotechnology methods continue to be planted on more acres and continue to deliver more tangible impacts in the United States. In 2002, the National Center for Food and Agricultural Policy assembled a comprehensive report, "Plant Biotechnology: Current and Potential Impact for Improving Pest Management in U.S. Agriculture." The study documented higher yields, higher farm incomes, and reduced pesticide use due to extensive adoption of biotechnology-derived crops in 2001. The updated study found that the positive impacts continued to increase as 26 million more acres were planted to more varieties of biotechnology-derived crops in 2003.

Similar to 2001, American growers planted six biotechnology-derived crops in 2003 — canola, corn, cotton, papaya, soybean, and squash. With the introduction of three new traits for corn and cotton in 2003, the number of biotechnology-derived varieties increased to 11, compared with eight in 2001. They included virus-resistant papaya and squash; herbicide-tolerant canola, corn, cotton, and soybean; and insect-resistant corn (three applications) and cotton (two applications).

Production and economic impacts

Case studies of these 11 biotechnology-derived varieties showed that crop yields increased by 5.3 billion pounds, saved growers $1.5 billion by lowering production costs, and reduced pesticide use by 46.4 million pounds. Based on increased yields and reduced production costs, growers realized a net economic impact or savings of $1.9 billion. Compared with 2001, that represented a 41 percent increase in yield gain, 25 percent greater reduction in production costs, and 27 percent higher economic return in 2003.

Further increases in crop production and grower returns are expected as more acres are planted with rootworm-resistant corn hybrids. The rootworm is the most destructive pest in corn, the country's largest commercial crop. Introduced in the market in 2003, rootworm-resistant corn was planted on 0.34 million acres and increased crop production by 86 million pounds. Acreage planted to rootworm-resistant corn increased tenfold in 2004 to about 3 million acres. Based on 2004 adoption data, corn growers increased production by 754 million pounds in 2004. Seed supply has been the limiting factor, and as more rootworm-resistant seed becomes available in the marketplace, the number of acres planted with the crop is expected to increase significantly.

Pesticide use impacts

The 11 varieties planted in 2003 also reduced the use of pesticides by a total of 46.4 million pounds, compared with 45.7 million pounds in 2001 (Table 1). The reduction in pesticide use was slightly higher (2 percent) in 2003 over 2001. Herbicide-tolerant soybean still accounted for much of the reduction in pesticide use at 20 million pounds.

The biggest reduction in pesticide use was in cotton and corn when soybean was not included in the analyses. In fact, when soybean is excluded, the reduction of pesticides in other biotechnology-derived crops was 9.4 million pounds, or 55 percent higher in 2003 than in 2001. For insect-resistant crops alone, the reduction in pesticide use was 2.7 million pounds, or 61 percent higher while it was 6.7 million pounds, or 54 percent higher, in herbicide-tolerant crops (excluding soybean) in 2003 than in 2001.

Reductions in pesticide use are expected to further increase as more acres are planted with rootworm-resistant corn hybrids. Based on 2003 acreage, rootworm-resistant corn reduced pesticide use by 225,000 pounds. It is projected that corn growers reduced insecticide use by an estimated 1.98 million pounds in 2004, based on typical insecticide use of about 0.66 pounds per acre for corn rootworm control.

Crop impacts

The 11 planted biotechnology-derived crop varieties had significant impact on U.S. agriculture in 2003. The greatest yield increase resulted from insect-resistant corn at 4.9 billion pounds, followed by insect-resistant

Table 1 [illegible]

Year	Planted acreage	Yield increase	Reduction in production costs	Net economic impact	Pesticide use reduction[1]
	Million acres	Billion pounds	Billion dollars	Billion dollars	Million lbs.
2003	106	5.34	1.5	1.9	46.4
2001	80	3.79	1.2	1.5	45.7

[1]Refers to active ingredients.

Table 2 [illegible]

Case study	Crop	Trait	Percentage adoption	
			[illegible]	[illegible]
1	Papaya	Virus-resistant	46	37
2	Squash[a]	Virus-resistant	19	17
3	Canola	Herbicide-tolerant	75	70
4	Corn	Herbicide-tolerant	14	8
5	Cotton	Herbicide-tolerant	74	59
6	Soybean	Herbicide-tolerant	82	69
7	Corn	Insect-resistant (1)[b]	30	21
8	Corn	Insect-resistant (2)[c]	0.5	—
9	Corn	Insect-resistant (3)[d]	0.6	—
10	Cotton	Insect-resistant (1)[e]	46	42
11	Cotton	Insect-resistant (2)[f]	0.2	—

[a]Adoption in GA and FL only
[b]European corn borer/southwestern corn borer/corn earworm-resistant corn (includes YieldGard Corn Borer and Herculex I)
[c]Rootworm-resistant corn (YieldGard Rootworm)
[d]European corn borer/southwestern corn borer/black cutworm/fall armyworm/corn earworm-resistant corn (Herculex I)
[e]Bollworm and budworm-resistant cotton (Bollgard I)
[f]Bollworm/budworm/looper/armyworm-resistant cotton (Bollgard II)

cotton at 0.37 billion pounds. Cost savings were greatest from herbicide-tolerant soybean at $1.2 billion and herbicide-tolerant cotton at $0.23 billion. Reduction in pesticide use was greatest due to herbicide-tolerant soybean at 20 million pounds and herbicide-tolerant cotton at 9.6 million pounds.

State Impacts

The study found that each of the 42 states where the 11 crop varieties were planted realized significant benefits. Overall, impacts were greatest for Iowa, Illinois, and Minnesota because of their large acreage of corn and soybean. Iowa led the way in increases in production, net economic impact, and further reductions in pesticide use (1.08 billion pounds, $239 million, and 7.5 million pounds, respectively). Illinois and Minnesota experienced the second and third greatest economic impacts, respectively. Iowa's 7.5 million pound reduction in pesticide use was mainly due to Bt and herbicide-tolerant corn and herbicide-tolerant soybean, followed by Minnesota with a 6.6 million pound reduction, and Illinois with 6.5 million pounds.

Study Background and Purpose

The first generation of biotechnology-derived crops was commercialized in 1996 in the United States, and planting has expanded every year since to a total of 106 million acres in 2003. Planted acreage has concentrated in three applications (herbicide-tolerance, insect-resistance, and virus-resistance) and six crops (canola, corn, cotton, papaya, soybean, and squash).

In 2002, the National Center for Food and Agricultural Policy assembled "Plant Biotechnology: Current and Potential Impact for Improving Pest Management in U.S. Agriculture." The study estimated the aggregate production and economic impacts of the extensive adoption of eight crop varieties planted in 2001. It also projected the impacts for 32 additional biotechnology-derived cultivars that were either under development or not yet adopted.

Since 2001, the number of acres planted to biotechnology-derived crops has increased 26 million acres and new varieties — Bt corn (YieldGard Rootworm), Bt corn (Herculex I), and Bt cotton (BollGard II) — have been approved and planted. The National Center for Food and Agricultural Policy embarked on a second study in 2004 to update the data. The study strictly focused on crops that were planted in 2003. Impacts were assessed for 11 planted crop varieties in 2003 (Table 2), including biotechnology-derived crops with new pest management traits that were grown for the first time. Similar to the previous report, the 2004 study identified and quantified impacts on production volume, value, costs, and pesticide use. Impacts of biotechnology-derived crops on other production practices such as tillage also were included.

Changes in production volume were measured based on yield changes that have occurred when biotechnology-derived crops replaced conventional crops. Similarly, change in production value was calculated based on the yield changes and crop prices. Changes in production costs were calculated by determining which current practices would be affected. Adoption costs associated with the use of the technology (either as technology fee or seed premium or both) were considered in the calculations. Finally, changes in pesticide use were quantified when the biotechnology-derived crop cultivar has replaced or substituted the current use of the target pesticides leading to either an increased or reduced usage. The impacts were calculated using 2003 acreage, for which the U.S. Department of Agriculture's National Agricultural Statistics Service served as a valuable resource.

University researchers and university extension crop specialists were surveyed to evaluate existing pest management approaches in conventional crops and to determine how biotechnology-derived crops replaced or substituted current practices. Updated estimates, contained within 11 case studies, were sent to relevant external reviewers for comment, and their comments were integrated into the final report. In total, the report was reviewed by 26 agriculture, pest management, and plant biotechnology experts from 20 academic and government institutions.

The full report containing all 11 case studies can be accessed at www.ncfap.org.

ADOPTION OF BIOTECHNOLOGY-DERIVED CROPS IN 2003

Biotechnology-derived crops with built-in or enhanced protection against key pest problems offered the best results, as reflected by increased adoption rates in 2003 (Table 2). Among the biotechnology-derived crops planted in 2003, adoption of herbicide-tolerant soybean was the highest at 82 percent, followed by herbicide-tolerant canola (75 percent) and herbicide-tolerant cotton (74 percent). Comparisons between 2001 and 2003 suggested that expansion in the planted acreage was greatest for herbicide-tolerant corn (69 percent), followed by Bt corn (43 percent). Adoption of the

Table 3 [illegible]

Case Study	Crop	Trait[1]	Production			Total net value	Reduction in pesticide use	Acreage[2]
			[illegible]	[illegible]	[illegible]	Million $	lbs. ai[3]	Acres
1	Papaya	VR	8.98	2.96	0.05	2.91	0	1,095
2	Squash	VR	24	6.99	0.43	6.56	0	1,815
3	Canola	HT	0	0	-8.98	8.98	154,740	728,000
6	Soybean	HT	0	0	-1,190	1,190	20,059,000	59,393,000
7	Field Corn	IR - I	4,692	205.3	58.7	146.6	3,622,046	21,345,000
8	Field Corn	IR - II	85.5	3.76	1.36	2.4	224,557	340,239
9	Field Corn	IR - III	163	7.3	-2.41	9.7	40,086	472,512
4	Field Corn	HT	0	0	-99.69	99.69	9,429,000	9,821,000
10	Cotton	IR – I	362.94	181.47	-9.47	190.94	3,203,650	6,129,000
11	Cotton	IR – II	2.27	1.48	0.52	1.22	38,224	30,677
5	Cotton	HT	0	0	-220.97	220.97	9,621,000	9,889,000
Total			**5,339**	**409**	**-1,471**	**1,880**	**46,392,303**	

[1]Trait: VR, virus resistance; HT, herbicide tolerance; IR, insect resistance.
[2]Acreage is not totaled because, in some cases, cultivars with multiple traits could be planted on the same acre.
[3]ai refers to active ingredients.

Table 4 [illegible]

Trait	Production			Total net value	Reduction in pesticide use
	[illegible]	[illegible]	[illegible]	Million $	Million lbs. ai[1]
Herbicide-tolerance	0	0	-1,519.64	1,519.64	39.2
Insect-resistance	5,305.71	399.31	48.7	350.86	7.2
Virus-resistance	32.98	9.95	0.48	9.47	0
Total	**5,339**	**409**	**-1,471**	**1,880**	**46.4**

[1]ai refers to active ingredients.

new Bt varieties was less than 1 percent in 2003, due to limited seed supplies in the introductory year. Adoption of these new crop traits has increased in 2004 and is expected to increase significantly in the next few years.

In general, herbicide-tolerant crops were planted on a large scale in 2003, while the use of insect-resistant or virus-resistant crops varied based on the anticipated level of infestation of target pests. Adoption of these crops, Bt crops in particular, may continue to increase in the future as new varieties were commercialized in 2003 to combat important pest problems.

Results

Findings from the 2004 study suggest that biotechnology-derived crops have continued to deliver tangible economic and environmental benefits in 2003 in the United States. The widespread adoption of genetically modified canola, corn, cotton, papaya, soybean, and squash has correlated significantly with increased crop yields, reduced reliance on pesticides, and reduced farm production costs (Table 3). The findings strongly suggest continuing significant gains in net grower returns.

Similar to 2001, yield impacts were greatest for insect-resistant crops in 2003, also due to season-long protection from insect pest problems. On the other hand, the greatest economic impacts were realized from herbicide-tolerant crops. Herbicide-tolerant crops aided in effective control of weeds with fewer herbicides and fewer applications. Costs associated with tillage and handweeding were reduced in crops such as cotton. All these impacts have translated to significant grower cost savings. Overall pesticide use in 2003 was 46.4 million pounds lower than it would have been without the use of biotechnology-derived crops. Pesticide use was significantly reduced in all crops except papaya and squash.

Impacts by trait

Insect-resistant crops accounted for 99 percent of the yield improvement due to biotechnology-derived crops in 2003 (Table 4). Bt crops had significantly reduced insect damage, which translated to improved yields of 5.3 billion pounds. Herbicide-tolerant crops did not show an impact on crop yields, as weed management associated with biotechnology-derived crops provided weed control equivalent to conventional methods. Herbicide-tolerant crops, on the other hand, were associated with greatest savings in costs, greatest net returns, and largest reductions in pesticide use. The greatest economic impacts due to herbicide-tolerant crops are attributed to soybean, which are associated with reduced weed management costs of $1.2 billion. The four herbicide-tolerant crops planted in 2003 contributed to reductions in total herbicide use of about 39 million pounds. Reduction in pesticide use due to herbicide-tolerant crops was 5.5 times higher than that noted with Bt crops. While pesticide use has remained unchanged with the virus-resistant crops, significant increases have been noted in yields of these crops (33 million pounds).

Impacts by crop

Averaged across the crops, yield increase was greatest from corn at 4.94 billion pounds, with corn resistant to borers accounting for 95 percent of the increase (Table 5). Biotechnology-derived soybean showed the greatest reduction in production costs ($1.2 billion) and greatest improvement in net grower returns ($1.2 billion), largely resulting from extensive adoption of herbicide-tolerant soybean. After soybean, net

RESULTS

Table 5 [illegible]

#	Crop	Production			Total net value	Reduction in pesticide use	Acreage
		[illegible]	[illegible]	[illegible]	Million $	lbs. ai[1]	Acres
1	Papaya	8.98	2.96	0.05	2.91	0	1,095
2	Squash	24	6.99	0.43	6.56	0	1,815
3	Canola	0	0	-8.98	8.98	154,740	728,000
4	Soybean	0	0	-1,190	1,190	20,059,000	59,393,000
5	Field Corn	4,941	216.36	-42.04	258.39	13,315,689	31,978,751
6	Cotton	365.21	182.95	-229.92	413.13	12,862,874	16,048,677
Total		5,339	409	-1,471	1,880	46,392,303	

[1]ai refers to active ingredients.

returns were higher for cotton. Pesticide use reduction was greatest in soybean (20 million pounds), followed by corn (13.3 million pounds) and cotton (12.9 million pounds), mainly due to herbicide-tolerant varieties.

Comparisons between 2001 and 2003 estimates indicate that net economic impacts were reduced for only canola (18 percent reduction). A 20 percent decrease in acreage planted to herbicide-tolerant canola along with modification in impact assessment methodology accounts for this reduction. Unlike the 2002 report where impacts for glyphosate-tolerant and glufosinate-tolerant canola were averaged, impacts were calculated separately for glyphosate and glufosinate-tolerant varieties in 2003. Weed management systems utilizing glufosinate-tolerant canola are 21 percent costlier than for glyphosate-tolerant canola. Therefore, higher adoption rate of glufosinate-tolerant canola reduced the economic impact in 2003. Overall, a drop in planted canola acreage and costs associated with glufosinate-tolerant canola are the reasons for lower economic impact in 2003 compared with 2001.

Impacts by state

Table 6 depicts the estimated impact of biotechnology-derived crops by state, based on data from 42 states. Iowa had the greatest increase in production, highest net returns, and largest reduction in pesticide use specifically due to the adoption of biotechnology-derived corn and soybean. Following Iowa were Nebraska and Minnesota, the states that realized greatest gains in production due to biotechnology-derived crops in 2003. Illinois and Minnesota experienced the second and third greatest economic impacts, respectively. Iowa represented about 16 percent of the total reduction in pesticide use, mainly due to Bt and herbicide-tolerant corn and herbicide-tolerant soybean, followed by Minnesota and Illinois (both 14 percent).

Aggregate Impacts

Altogether, the 11 crop varieties improved yields by 5.3 billion pounds, increased grower net income by $1.9 billion, and reduced pesticide use by 46.4 million pounds in 2003 (Table 1). In comparison with 2001, biotechnology-derived crops improved yields by 41 percent, increased net returns by 27 percent, and reduced pesticide use by two 2 percent more in 2003, due to increases in crop acreage and planting of new varieties.

The relatively slight increase in the reduction of pesticide use in 2003 over 2001 was due to two biotechnology-derived crops: herbicide-tolerant canola and soybean. A 20 percent decrease in acreage planted to herbicide-tolerant canola accounted for a lower reduction in herbicide use in canola in 2003. Weed management programs (herbicides, herbicide programs, and use rates) that provided soybean weed control equivalent to that of glyphosate (as suggested by weed specialists) changed in 2003. Total herbicide use for suggested weed management programs in conventional soybean was lower in 2003 compared with the ones suggested in 2001. Therefore, difference in average herbicide use between biotechnology-derived and conventional system was lower in 2003 (0.34 lb ai/A) than in 2001 (0.57 lb ai/A), which

Table 6 [illegible]

State	Production			Total net value	Pesticide use
	[illegible]	[illegible]	[illegible]	000 $	000 lbs. ai[1]
Alabama	9,128	4,564	-11,426	15,990	-655
Arkansas	99,450	32,998	-97,963	130,941	-3,064
Arizona	17,315	6,129	-6,579	12,704	-389
California	10,290	5,145	-27,850	32,995	-776
Colorado	97,563	4,267	-249	4,613	-149
Connecticut	728	32	-21	53	-4
Delaware	10,304	451	-4,241	4,692	-166
Florida	4,990	2,150	-774	2,821	-205
Georgia	53,833	18,835	-20,988	38,574	-2,279
Hawaii	8,960	2,960	53	2,910	0
Idaho	0	0	-142	142	-13
Illinois	452,464	19,798	-157,340	176,898	-6,502
Indiana	74,734	3,272	-171,531	174,592	-6,281
Iowa	1,079,275	47,352	-192,447	238,931	-7,481
Kansas	309,863	13,569	-29,708	43,217	204
Kentucky	56,784	2,483	-7,940	10,423	433
Louisiana	72,148	15,182	-25,789	40,896	-843
Maryland	60,872	2,663	-5,696	8,359	-343
Massachusetts	168	6	-8	14	-1
Michigan	73,419	3,214	-27,662	31,428	225
Minnesota	525,975	23,012	-153,721	176,619	-6,594
Mississippi	86,187	32,886	-61,816	94,555	-2,195
Missouri	311,369	23,017	-91,644	114,630	-4,438
North Carolina	36,354	11,215	-40,541	51,729	-1,452
North Dakota	58,240	2,549	-49,104	51,653	1,154
Nebraska	743,375	32,525	-49,497	81,716	-2,781
New Jersey	4,200	183	-1,357	1,539	-68
New Mexico	8,708	1,083	-739	1,822	-80
New York	4,368	192	-3,758	3,950	-204
Ohio	23,047	1,010	-68,586	69,585	1,254
Oklahoma	44,332	5,712	-7,940	13,652	-208
Pennsylvania	37,968	1,658	-4,246	5,904	-310
South Carolina	19,294	1,708	-8,700	10,392	-26
South Dakota	468,639	20,503	-55,862	76,357	458
Tennessee	72,148	21,307	-36,321	57,628	-1,580
Texas	281,442	39,246	-35,338	74,584	-1,473
Utah	0	0	-51	51	-5
Virginia	6,985	1,348	-6,307	7,651	-319
Vermont	2,184	96	-11	107	-7
West Virginia	1,176	51	-151	202	-310
Wisconsin	109,796	4,805	-9,739	14,482	1,090
Wyoming	0	0	-71	71	-7

[1] ai refers to active ingredients.

Table 7 [illegible]

Trait	Crop	2001	2003	Pesticide use reduction
		Million lbs.[1]		% increase in 2003
Herbicide-tolerant	Corn	5.81	9.43	62
Herbicide-tolerant	Cotton	6.17	9.62	56
Insect-resistant	Corn	2.6	3.89	50
Insect-resistant	Cotton	1.87	3.24	73

[1]Refers to active ingredients.

accounted for most of the lower than anticipated reduction in pesticide use. Reduction in pesticide use due to biotechnology-derived crops was 16.98 million pounds and 26.33 million pounds in 2001 and 2003, respectively, when soybean was excluded from the analysis. Thus, pesticide use reduction in other biotechnology-derived herbicide-tolerant crops (excluding soybean) was 54 percent higher in 2003, compared with 2001. For insect-resistant crops alone, pesticide use reduction was 61 percent higher in 2003 compared with 2001.

Comparative analysis of pesticide use reduction in biotechnology-derived crops (excluding canola and soybean) in 2003 and 2001 is presented in Table 7. Analysis indicated that the reduction in pesticide use grew 62, 56, 50, and 73 percent in 2003 in herbicide-tolerant corn, cotton, insect-resistant corn and cotton, respectively, compared with 2001.

Biotechnology-derived crops and no-tillage

In addition to agronomic and economic impacts, the adoption of biotechnology-derived crops has led to other environmental impacts. Conservation tillage practices, no-till in particular, have increased significantly since the adoption of biotechnology-derived herbicide-tolerant crops. Grower surveys and expert polls strongly indicate that the adoption of herbicide-tolerant crops correlated positively with increase in no-till acreage since 1996, the year when herbicide-tolerant crops were first planted.

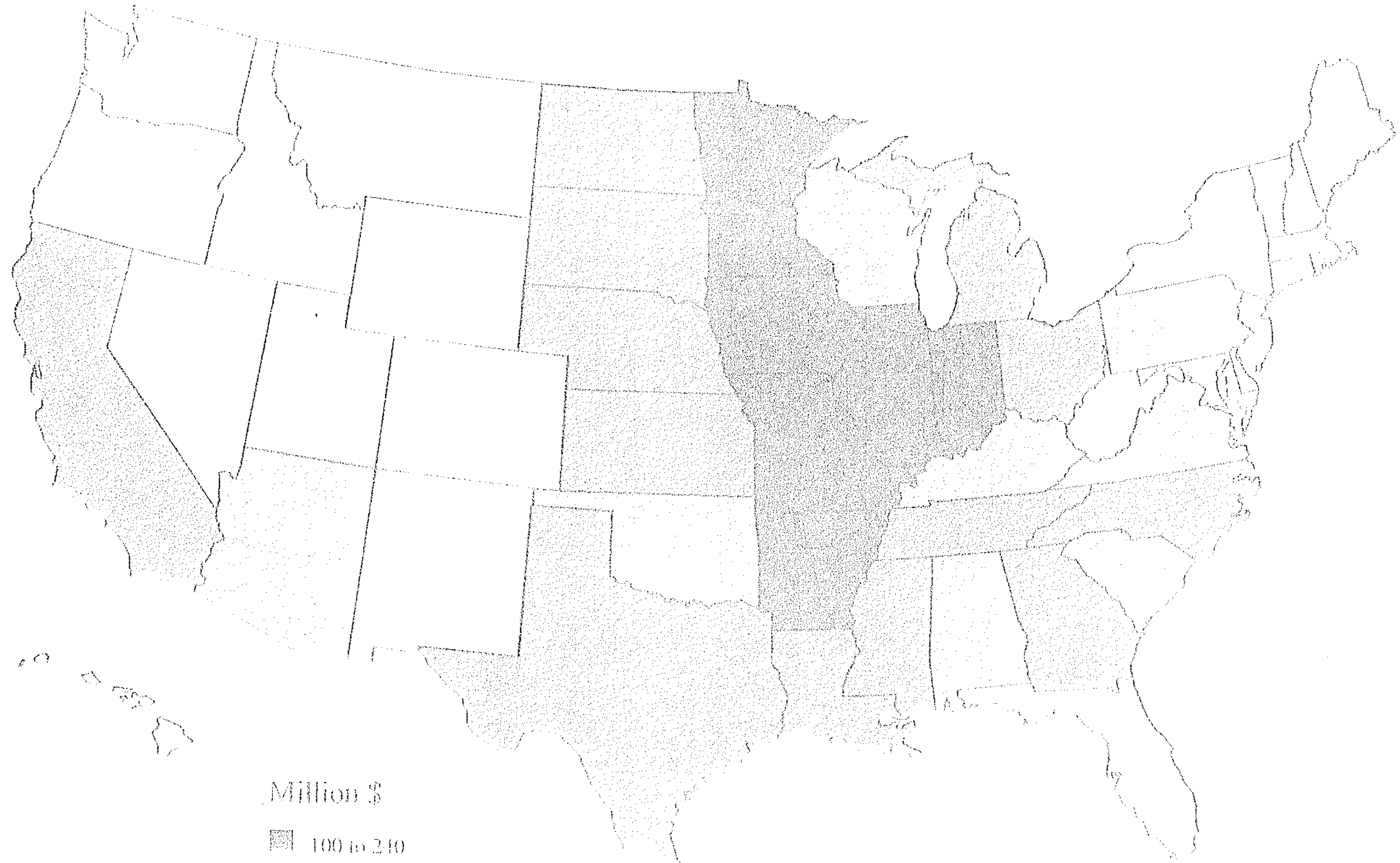
Weed control is a major concern in no-till fields when poor weather conditions hamper the effectiveness of herbicides. Herbicide-tolerant crops increased growers' confidence in their ability to control weeds without relying on tillage because herbicides used in biotechnology-derived crops are more effective than those used before. With that increased confidence, American growers planted 45, 14, and 300 percent more acres to no-till in soybean, corn, and cotton, respectively, in 2003, compared with years before their introduction.

The Conservation Technology Information Center (CTIC) reported in 2002 that increased use of conservation tillage practices such as no-tillage reduced soil erosion by nearly 1 billion tons and saved $3.5 billion in sedimentation treatment costs. Other benefits from no-tillage included significant fuel savings (3.9 gallons of fuel per acre), reduced machinery wear and tear, reduction of pesticide use (70 percent), less water runoff (69 percent), reduction in greenhouse gases due to improved carbon sequestration, and improved habitat for birds and animals. Some experts have credited herbicide-tolerant crops for transforming American agriculture from a carbon intensive operation to a potential carbon sink. By providing more ensured weed control, biotechnology-derived herbicide-tolerant crops facilitated the increase in no-till production practices and the associated environmental and economic benefits.

Conclusion

Economic advantage to growers is the ultimate key factor that determines the adoption and success of biotechnology-derived crops. This study found that American growers planted 106 million acres with biotechnology-derived crops in 2003 because improved pest control at lower cost improved their bottom lines, with those improvements increasing in tandem with increased acreage planted to these crops. The fact that adoption of biotechnology-derived crops has continued to grow each year since they were first introduced is testimony to the ability of these products to deliver tangible positive impacts and to the optimistic future they hold.

Benefits of biotechnology adoption by state



All 42 states included in the study derived economic benefits from biotech crops.

The Economic Status and Performance of Plant Biotechnology in 2003:

Adoption, Research and Development in the United States

December 2003

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The study was supported by the Council for Biotechnology Information. Its results are those of the authors alone and not the University of Minnesota.

The full report can be accessed at www.apec.umn.edu/faculty/frunge/plantbiotech.pdf.

EXECUTIVE SUMMARY

INTRODUCTION

Plant biotechnology in the United States is a growing industry offering remarkable economic, social and environmental opportunities in the years ahead. The adoption of biotech crops by farmers has been rapid and profitable. Progress on the research front has moved into a new phase, with biotech traits promising an increasingly wide range of consumer and environmental benefits. Plant biotech is also creating new jobs — and good jobs — beyond the farm gate. Sustaining the revolution in plant biotechnology will require a continued commitment to both public and private sector research and development.

- The purpose of this study is to put progress in plant biotechnology in context, and to appraise both its current place and likely future. It is an economic assessment of the status and performance of plant biotechnology and ongoing research and development in the United States.

- The study is focused on eight crops: corn, soybeans, cotton, rapeseed/canola, wheat, potatoes, sugar beets and rice. Given this focus it assesses four fundamental issues:

    1) What is the current level of adoption of plant biotechnology and its value to producers and how have adoption decisions affected farm-level profits in the United States?

    2) What are the main R&D activities in plant biotechnology, by crop and by trait, in both the private and public sector, based on available data?

    3) What are the probable economic impacts of the technology beyond the farm gate in the creation of jobs and new economic opportunities, and what role do individual states play in value creation and research?

    4) What is the future direction of both public and private R&D for the plant biotechnology sector?

- The 2003 levels of adoption of biotech corn, soybeans, cotton and rapeseed/canola in the U.S. were 40 percent for corn, 81 percent for soybeans, 73 percent for cotton and 70 percent for rapeseed/canola. (See Figure 1.) All four crops have shown steady increases in adoption rates. These biotech adoption rates result directly from increases in farm-level profits. Estimates vary by crop and by area, but average profits rose from $5 to as much as $60 per acre for corn, on the order of $15 per acre for soybeans and from $15 to several hundred dollars per acre for cotton.

- The main R&D activities in plant biotechnology are conducted by large private companies such as Syngenta, Monsanto, Bayer CropScience, DuPont, Dow AgroSciences and BASF. Together, these companies spent $2.7 billion on R&D in 2002, much of it on biotech. Scores of smaller start-ups are also engaged in the R&D process. In the public sector, research by the U.S. Department of Agriculture, land-grant universities and other academic research centers resulted in billions of dollars in additional research investment. In 2000, total U.S. public agricultural research spending was $3.5 billion. New biotech traits are now commercialized for corn, soybeans, cotton and rapeseed/canola, especially traits conferring insect and herbicide resistance. Scores of new traits in the pipeline were field tested by both private and public institutions from 2001 to mid-2003.

- The economic impacts of plant biotechnology are also increasingly evident beyond the farm gate, and in individual states active in biotech research and development. Beyond the more than $20 billion in biotech crops grown in 2002, new plant biotech firms and research facilities are being created throughout the U.S. Agricultural and food scientists are increasingly attracted to the biotech sector's above average wages, and a large number of individual states are reaping the benefits of this investment and job-related economic activity.

- The future direction of both public and private research and development in plant biotechnology will affect and be affected by producers, the input supply industry, private research and development investments, educational and research institutions, the federal government and increasingly consumers.

Current Adoption, Value and Profitability

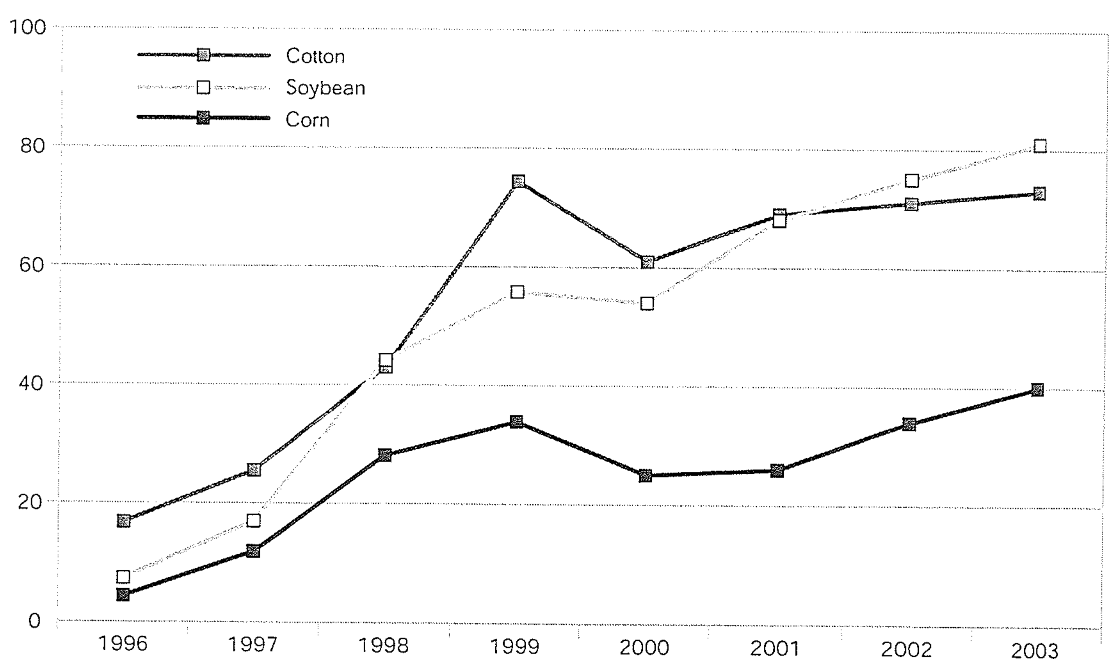
- The growth of value and benefits of plant biotechnology explain producer demand for biotech varieties in the U.S. Adoption rates for corn rose from 4 percent of corn acres in 1996 to 40 percent in 2003, worth $7 billion in 2002. Biotech soybeans rose from 9 percent of planted soybean acres in 1996 to 81 percent in 2003, worth $11 billion in 2002. Biotech cotton rose from 17 percent of planted cotton acres in 1996 to 73 percent in 2003, worth $2.7 billion in 2002. Biotech rapeseed/canola accounted for 70 percent of all acres planted in 2003, worth $115 million in 2002. All told, over $20 billion in crop value was associated with biotech crop varieties in 2002, half of the total value of the four crops.

- When evaluated state-by-state, four states (Iowa, Illinois, Minnesota and Nebraska) accounted for 60 percent of the value of biotech corn production. Four states (Iowa, Illinois, Minnesota and Indiana) accounted for 54 percent of the value of biotech soybean production. Four states (Texas, California, Mississippi and Georgia) accounted for 68 percent of the value of biotech cotton production. Two states (North Dakota and Minnesota) accounted for 95 percent of the value of biotech rapeseed/canola production. (See Figures 2, 3 and 4.)

- In 2003, no biotech varieties of wheat, potatoes, sugar beets or rice were planted commercially, although grower organizations remain keenly interested in ongoing research and development of the technology.

- Numerous studies have estimated the benefits of adopting biotech varieties for producers. A survey of these studies shows widespread improvements in profits and management capacity compared with conventional crops.

Figure 1
Percent of Crop Acres Planted to Biotech Varieties: 1996-2003



Source: USDA, NASS.

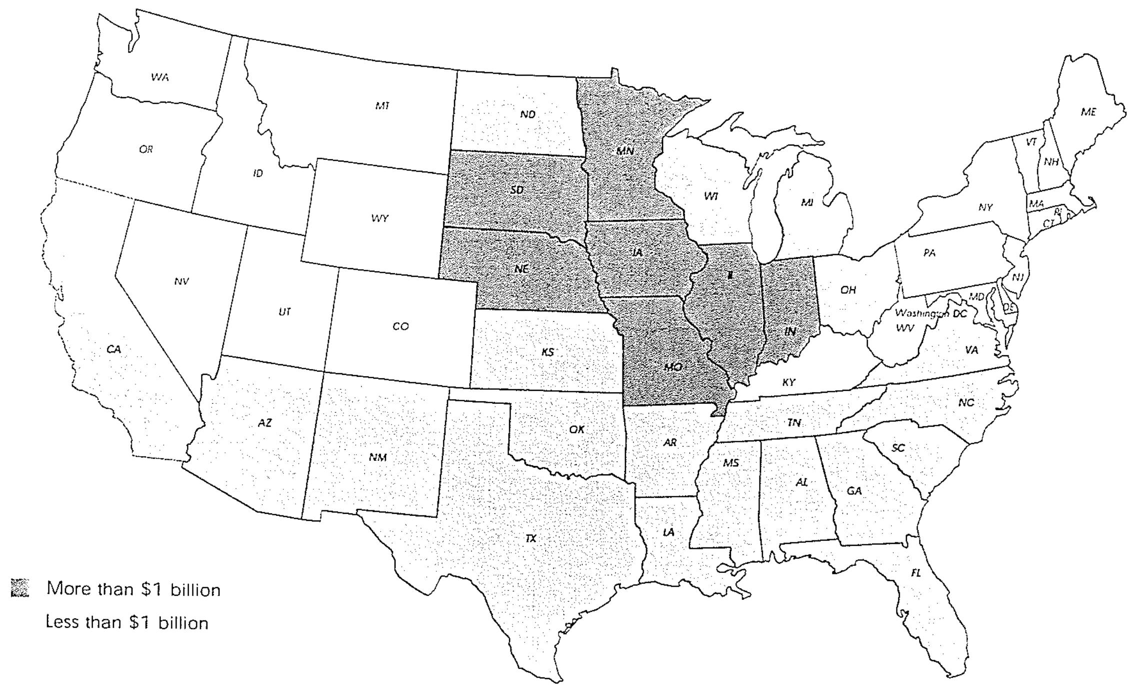
Figure 2
Value of Crops with Biotech Traits by State: 2002 (millions of dollars)*

2002	All Biotech	Soybean	Corn	Cotton	Canola
U.S.	$ 20,889	$ 11,026	$ 7,040	$ 2,708	$ 115
IA	3,816	2,004	1,811		
IL	2,546	1,756	790		
MN	2,154	1,151	995		8
NE	1,841	802	1,039		
IN	1,258	1,057	201		
SD	1,023	581	441		
MO	1,005	661	236	108	
ND	689	275	312		102
AR	670	371		299	
OH	619	562	57		
MS	528	195		334	
WI	498	274	224		
TX	489			489	
MI	427	309	118		
CA	404			404	
GA	329			329	
KS	274	262		12	
TN	138			138	
NC	137			137	
LA	126			126	
AZ	119			119	
AL	101			101	
OK	31			31	
NM	31			31	
SC	21			21	
VA	17			17	
FL	13			13	
Other	1,588	766	816	—	6

Source: USDA, NASS.

*USDA reports only the top 12-14 corn and soybean growing states for biotech varieties, allocating the rest to the "other" category. When these states are paired with USDA data on biotech cotton, the result is to underestimate biotech corn and soybeans in those states growing biotech cotton.

Figure 3
States with Major Biotech Crop Value: 2002*



*Four biotech crops (corn, soybeans, cotton, rapeseed/canola)

Private and Public R&D by Crop and by Trait

• Suppliers of plant biotechnology include numerous private and public sector actors. In the private sector, although hundreds of companies are invested in some aspect of plant biotechnology, six companies lead the sector: Syngenta, Bayer, Monsanto, DuPont, Dow and BASF. In 2002 these six companies together had sales in their agricultural divisions of roughly $28 billion. When research and development investments are calculated as a percentage of these sales, they average about 10.8 percent.

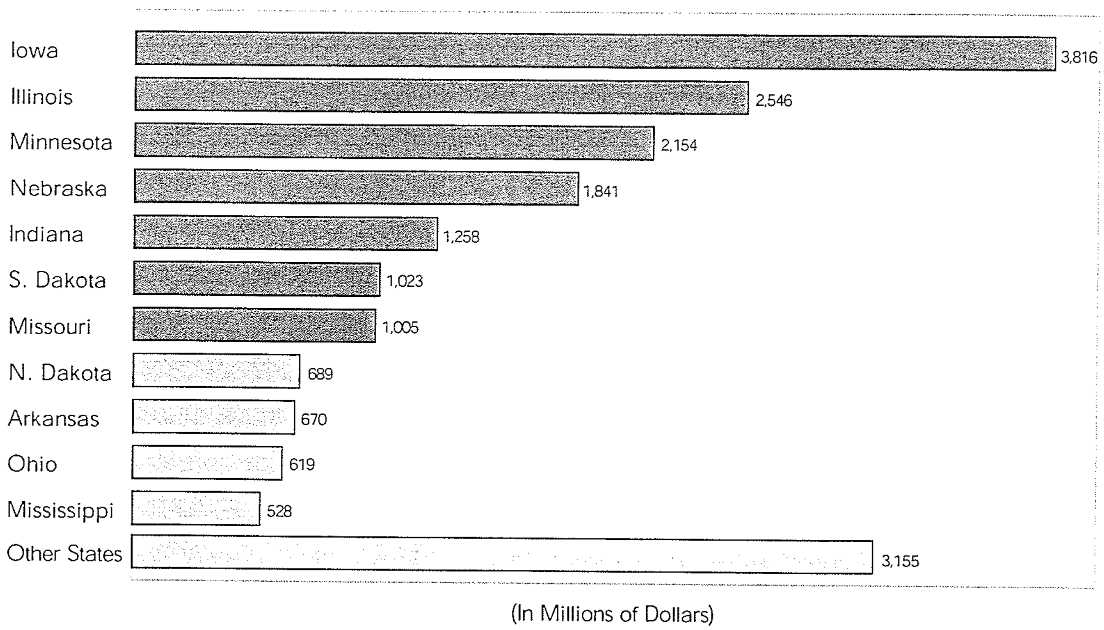
• Despite the dominance of large biotech companies, there are many examples of smaller companies that have found niche markets in the industry. Illustrative examples include Mendel Biotechnology, Arcadia Biosciences and Shoffner Farm Research, which are briefly surveyed.

• Plant biotech research rests on a wider platform of genomics, which is the latest episode in a tradition of modern plant breeding going back over a century. The cumulative nature of the research process means that research and development by both private and public plant scientists has accumulated over more than 100 years. It is the *accretion* of this knowledge, and not just its leading edges, that defines the R&D mission in plant genetics, including plant biotech.

• Estimates of the stock of plant breeding knowledge and its value, compared with the value of agricultural output, show that from 1850 to 1995 (allowing for depreciation of past research) the ratio of value was 10:1. In other words, in 1995, for every $100 of agricultural output there was $1,000 stock of knowledge to draw on.

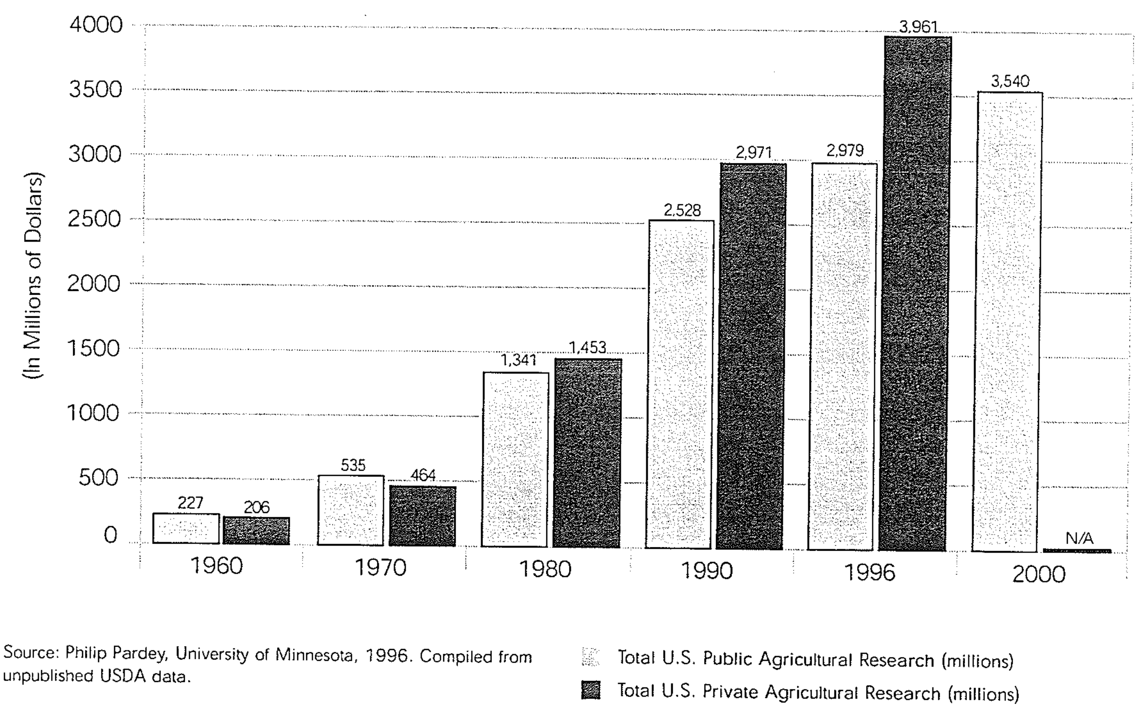
• The role of the public sector in plant science research relates specifically to this stock of knowledge, which is held in large part in the public domain by universities, experiment stations and federal research facilities. It also relates to the fact that agricultural research investments often pay out only after 20-30 years. The public sector is often the only party willing and able to wait for these payoffs to accrue.

Figure 4
Total Value of Biotech Crops in 2002 in the United States was $20.9 Billion



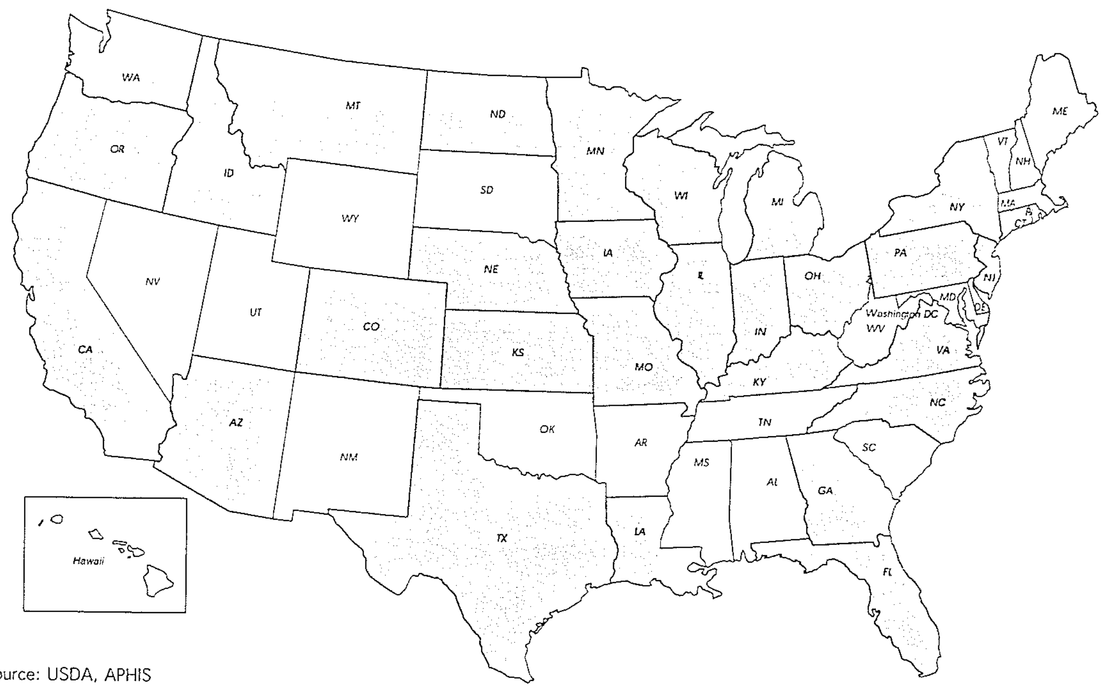
Source: USDA, NASS.

Figure 5
Public and Private U.S. Agricultural Research and Development Spending in Nominal Dollars, Selected Years



Source: Philip Pardey, University of Minnesota, 1996. Compiled from unpublished USDA data.

Figure 6
States Where Public Research Institutions Conducted Biotech Field Trials: 2001-2003*



Source: USDA, APHIS

*Eight biotech crops (corn, soybeans, cotton, rapeseed/canola, wheat, potato, rice, sugar beets)

- Despite this long accrual process, the social rates of return to these investments are impressive by any standards. In a 2000 study comparing estimates of rates of return to agricultural research from 292 studies since 1958, the average annual rate of return was an extraordinary 81 percent (77 percent after inflation) compared to 5 percent on U.S. government bonds in 2002. In corn research, the rate of return was 134.5 percent, in wheat 50.4 percent and in rice 75 percent.

- Biotech plants are the latest phase in this effort. The role of the public sector in these and forthcoming biotech innovations should not be discounted, despite substantial increases in the private share of agricultural research and development. If anything, returns to research in plant biotech will exceed the high rates calculated for agricultural research as a whole.

- In 1960, private R&D was 90 percent of public. During the 1970s, private R&D rose to outstrip public spending. By 1980 it exceeded it by 8 percent. In 1990 it exceeded it by 17 percent. By 1996 it was 32 percent higher. (See Figure 5.)

- The growth of private sector R&D in plant science grew most rapidly from 1960-1996 in plant breeding, which increased at an annual rate of 13.7 percent. From 1990-1996, plant breeding research grew at an annual rate of 9.4 percent, more than any other category of private agricultural R&D.

- Public sector research institutions in agriculture have operated largely through connections from USDA to the land grant Universities and their Experiment Stations. Knitting together the system of land grant institutions are various branches of USDA, notably its Agricultural Research Service (ARS), Cooperative State Research, Education and Extension Service (CSREES), Economic Research Service (ERS) and National Agricultural Statistics Service (NASS). USDA expenditures for the four programs in 2002 were $2.3 billion, of which CSREES accounted for nearly half. CSREES is the main federal partner with land grant research, teaching and extension activities. No budget items are designated "plant biotech," but ARS has a $314 million line item for plant sciences, and ERS has a small $1.1 million "genomics initiative."

- The changing emphasis of federally funded research is reflected in National Science Foundation data for 1990-99, which shows major gains in the share of the life sciences as a research category. Life sciences outstripped every other research category in its gains, and exceeded the gains of the next largest category, computer sciences, by more than 10 times. Between 1996 and 2002, nationwide NSF funding increased 70 percent in the biological sciences sector.

- Ongoing commercial activity in plant biotech and R&D in the pipeline were examined by describing all traits and varieties of biotech crops approved for commercial sale, and all plant biotech traits in field trials from 2001 to mid-2003. In the first case, USDA, FDA and EPA information was used to construct tables of commercial activity. In the second case, data from USDA's Agricultural Plant Health Inspection Service (APHIS) was used.

- Ongoing commercial activity shows a growing list of approvals in corn, soybeans, and cotton through 2001, mainly by the largest companies. In the remaining crops in the study, some approved varieties exist but are not being commercially sold.

- Plant biotech R&D in the pipeline as of 2001 through mid-2003 indicates almost a hundred new traits in testing. (See Figures 6, 7 and 8.) Represented in these activities are about 40 universities (mainly land grants) and about 35 private sector companies. Without question, more research and development as measured by field tests has been devoted to biotech traits in corn than to any other crop, attracting scores of public and private institutions. Among the traits in testing for corn were 19 new agronomic properties, four traits for fungal resistance, seven for herbicide tolerance, four for insect resistance, ten trials focusing on some form of marker genes, and over 30 for output and other end-use traits.

- Soybean research, in which the public and private sector are about equally represented, involved three field tests from 2001 to mid-2003 for agronomic properties, three for fungal resistance, eight for herbicide tolerance, one for insect resistance, one for marker genes, and eight for output traits related to product quality or environmental and health benefits to consumers.

- Cotton research was led from 2001 to mid-2003 by the six major private companies, one land grant and the Agricultural Research Service (ARS) of USDA. Testing of biotech traits focused on four agronomic properties, one fungal resistance trait, three herbicide resistance traits and one trait for insect resistance.

- Rapeseed/canola field testing was actively pursued by numerous smaller companies as well as major players such as Monsanto and Cargill and two state universities. Four tests were made on agronomic properties, one each on fungal resistance, herbicide tolerance, insect resistance, and marker genes. Four tests were conducted on output traits for enhanced product quality and alternative uses for canola oil.

- Wheat field testing was quite active despite the absence of marketed biotech varieties, reflecting continued interest in their commercial potential. Testing of agronomic properties related to starch, yield and drought tolerance was pursued at three land grants. Fungal resistance traits were tested by ARS, Syngenta and three land grants. Herbicide tolerance and virus resistance was tested by ARS, Monsanto and the University of Idaho. Marker genes were tested by Montana State. Finally, output traits for digestibility, starch metabolism, and improved bread making characteristics, among others, were tested by several small companies, as well as ARS and Montana State.

- Sugar beets also saw a limited number of field trials from 2001 to mid-2003, notwithstanding the absence of commercial sales. Two herbicide tolerant traits and a virus resistant trait were tested by Syngenta, Monsanto and two small privates.

- Rice was the subject of numerous field tests from 2001 to mid-2003, suggesting the potential opportunities once commercial markets open up. Two agronomic properties were tested by both large and small privates and two states. Bacterial resistance traits were tested by Louisiana State University and the University of California-Davis. Fungal resistance and herbicide tolerance were tested at Louisiana State and by Aventis and Monsanto. Insect resistance traits were tested by Syngenta. Marker genes were tested by the University of California-Davis, Louisiana State University and ExSeed Genetics. Lastly, output traits including heavy metal bioremediation, starch level changes, novel protein production and carbohydrate metabolism changes were tested by two small companies, as well as Aventis (now Bayer) and BASF.

- Potatoes were also the subject of considerable field testing of biotech traits from 2001 to mid-2003.

Traits tested include bacterial resistance by ARS, fungal resistance by Syngenta, ARS and three land grants, and insect resistance by Michigan State University and the University of Idaho. Virus resistance traits were tested at ARS, the University of Idaho and the Oregon State University. Gene marker traits were tested by Syngenta, ARS and two land grants. Last, a number of product quality traits were tested such as increased beta-carotene, starch content and reduced bruising properties. These tests involved major privates like Syngenta, potato producers such as J.R. Simplot, as well as ARS and several land grants.

Figure 7

Public Institutions Engaged in Plant Biotech Field Studies by State, Commodity and Trait: 2001-2003

Public Institution by state	Commodity	Trait in field study
Arizona		
U of Arizona	Corn	Endosperm DNA synthesis altered
U of Arizona	Corn	Visual marker
U of Arizona	Corn	Color sectors in seeds
U of Arizona	Corn	Pigment composition/metabolism altered
U of Arizona	Corn	Gene expression altered
U of Arizona	Corn	Anthocyanin produced in seed
California		
Stanford U	Corn	Visual marker
Stanford U	Corn	Seed color altered
Stanford U	Corn	Anthocyanin produced in seed
Stanford U	Corn	Transposon inserted/movement supressed
U of California	Corn	Fertility altered
U of California	Corn	Environmental stress reduced
U of California	Corn	Visual marker
U of California	Corn	Anthocyanin produced in seed
U of California/Berkeley	Corn	Seed color altered
U of California/Berkeley	Corn	Pigment composition/metabolism altered
U of California/Berkeley	Corn	Gene expression altered
U of California/Davis	Rice	Bacterial leaf blight resistant
U of California/Davis	Rice	Visual marker
U of California/San Diego	Corn	Phosphinothricin tolerant
Colorado		
Colorado State U	Potato	Phytophthora resistant
Connecticut		
U of Connecticut	Corn	Visual marker
Florida		
U of Florida	Corn	Male sterile
U of Florida	Corn	Color sectors in seeds
U of Florida	Corn	Starch metabolism altered
U of Florida	Corn	Seed size/weight increase
Georgia		
U of Georgia	Rapeseed	Lepidopteran resistant
U of Georgia	Rapeseed	Visual marker
U of Georgia	Soybean	Lepidopteran resistant
Hawaii		
Hawaii Agriculture Research Center	Rice	Yield increased
U of Hawaii	Corn	Polymer produced

Public Institution by state	Commodity	Trait in field study
Idaho		
U of Idaho	Potato	Colorado potato beetle resistant
U of Idaho	Potato	PLRV resistant
U of Idaho	Potato	PVY resistant
U of Idaho	Potato	TRV resistant
U of Idaho	Potato	Kanamycin resistant
U of Idaho	Potato	Bruising reduced
U of Idaho	Potato	Ethylene metabolism altered
U of Idaho	Wheat	BYDV resistant
U of Idaho	Wheat	WSMV resistant
Illinois		
U of Illinois	Corn	Phosphinothricin tolerant
U of Illinois	Corn	Visual marker
U of Illinois	Corn	Gene expression altered
U of Illinois	Corn	Epidermal cells increased on juvenile leaves
U of Illinois	Soybean	Phosphinothricin tolerant
Indiana		
Purdue U	Corn	Color sectors in seeds
Iowa		
Iowa State U	Corn	Male sterile
Iowa State U	Corn	Fertility altered
Iowa State U	Corn	Visual marker
Iowa State U	Corn	Starch metabolism altered
Iowa State U	Corn	Carbohydrate metabolism altered
Iowa State U	Corn	Protein altered
Iowa State U	Corn	Pharmaceutical proteins produced
Iowa State U	Soybean	Phytophthora resistant
Iowa State U	Soybean	Protein altered
Kansas		
Kansas State U	Corn	Color sectors in seeds
Kansas State U	Wheat	Drought tolerant
Kansas State U	Wheat	Fusarium resistant
Kentucky		
U of Kentucky	Soybean	BPMV resistant
U of Kentucky	Soybean	Oil profile altered
U of Kentucky	Soybean	Altered amino acid composition
U of Kentucky	Soybean	Methionine level increased
Louisiana		
Louisiana State U	Rice	Yield increased
Louisiana State U	Rice	Burkholderia glumae
Louisiana State U	Rice	Rhizoctonia solani resistant

Economic Impact Beyond the Farm Gate and the Role of the States

• Looking beyond the farm gate, it is clear that the plant biotech industry is creating jobs unknown a decade ago. The stock of knowledge associated with the R&D leading to the biotech revolution, if the formula developed by analysts of agricultural research is used, is worth at least $200 billion. Maintaining this stock of knowledge will require high skill levels and will demand high wages.

• The number of biological science degrees, one measure of this trend, rose dramatically in the 1990s. In the U.S. as a whole, the number of bachelor's, master's and Ph.D.'s in the biological sciences rose from 45,000 in 1990 to 73,000 in 2000, an increase of 62 percent.

Public Institution by state	Commodity	Trait in field study
Louisiana State U	Rice	Phosphinothricin tolerant
Louisiana State U	Rice	Hygromycin tolerant
Michigan		
Michigan State U	Potato	Phytophthora resistant
Michigan State U	Potato	Coleopteran resistant
Michigan State U	Potato	Lepidopteran resistant
Michigan State U	Potato	Visual marker
Michigan State U	Potato	Starch level increased
Minnesota		
U of Minnesota	Potato	Late blight resistant
U of Minnesota	Wheat	Phosphinothricin tolerant
Missouri		
U of Missouri	Corn	Gene expression altered
U of Missouri	Corn	Anthocyanin produced in seed
Montana		
Montana State U	Wheat	Starch level increased
Montana State U	Wheat	Yield increased
Montana State U	Wheat	Visual marker
Montana State U	Wheat	Improved bread making characteristics
Nebraska		
U of Nebraska/Lincoln	Soybean	Sclerotinia resistant
U of Nebraska/Lincoln	Soybean	Cyanamide tolerant
U of Nebraska/Lincoln	Soybean	Dicamba tolerant
U of Nebraska/Lincoln	Soybean	Oil profile altered
U of Nebraska/Lincoln	Soybean	Fatty acid level/metabolism altered
U of Nebraska/Lincoln	Soybean	Oleic acid content altered in seed
U of Nebraska/Lincoln	Wheat	Yield increased
U of Nebraska/Lincoln	Wheat	Fusarium resistant
New Jersey		
Rutgers U	Corn	Storage protein altered
Rutgers U	Corn	Visual marker
Rutgers U	Corn	Seed color altered
Rutgers U	Corn	Methionine level increased
New York		
Boyce Thompson Institute	Potato	Kanamycin resistant
Boyce Thompson Institute	Potato	Beta-carotene increased
Cold Spring Harbor Lab	Corn	Development altered
North Carolina		
North Carolina State U	Rapeseed	Visual marker

Source: USDA. APHIS

Public Institution by state	Commodity	Trait in field study
North Dakota		
North Dakota State U	Potato	Carbohydrate metabolism altered
Ohio		
Ohio State U	Corn	Visual marker
Oregon		
Oregon State U	Potato	PVY resistant
Pennsylvania		
Pennsylvania State U	Corn	Male sterile
Pennsylvania State U	Corn	Visual marker
Pennsylvania State U	Corn	Color sectors in seeds
Texas		
Texas Agricultural Exp Stn	Cotton	Rhizoctonia solani resistant
Texas Tech	Cotton	Carbohydrate metabolism altered
Texas Tech U	Cotton	Environmental stress reduced
Texas Tech U	Cotton	Fiber quality altered
Virginia		
Virginia Tech	Soybean	Phytate reduced
Washington		
Washington State U	Potato	Storage protein altered
Wisconsin		
U of Wisconsin	Corn	Altered maturing
U of Wisconsin	Corn	Visual marker
U of Wisconsin	Corn	Gene expression altered
U of Wisconsin	Corn	Anthocyanin produced in seed
USDA		
ARS	Cotton	Oleic acid content altered in seed
ARS	Potato	Erwinia carotovora resistant
ARS	Potato	Phytophthora resistant
ARS	Potato	PLRV resistant
ARS	Potato	PVY resistant
ARS	Potato	PVA resistant
ARS	Potato	Visual marker
ARS	Potato	Steroidal glycoalkaloids reduced
ARS	Soybean	Visual marker
ARS	Wheat	Phosphinothricin tolerant
ARS	Wheat	Powdery mildew resistant
ARS	Wheat	Smut resistant
ARS	Wheat	Storage protein altered

Figure 8
Public and Private Sector Institutions Filing for Field Testing Permits for Eight Study Crops Between January 2001 and July 2003*

Public Sector Institutions	Private Sector Institutions
ARS — USDA Agricultural Research Service	Abbott and Cobb
Boyce Thompson Institute (Cornell)	AgReliant Genetics
Cold Spring Harbor Lab	Applied PhytoGenetics, Inc.
Colorado State University	Applied Phytologics
Hawaii Agriculture Research Center	Arcadia Biosciences
Iowa State University	Aventis
Kansas State University	BASF
Louisiana State University	Bayer CropScience
Michigan State University	Betaseed
Montana State University	Biogemma
North Carolina State University	Cargill
North Dakota State University	Dow
Ohio State University	DuPont
Oregon State University	ExSeed Genetics
Pennsylvania State University	Garst
Purdue University	Goertzen Seed Research
Rutgers University	Horan Bros. Agri. Enterprises
Stanford University	Interstate
Texas Agricultural Exp Stn	Interstate Payco Seed
Texas Tech University	J. R. Simplot Company
University of Arizona	Mendel Biotechnology
University of California	Meristem Therapeutics
University of California/Berkeley	Monsanto
University of California/Davis	National Starch & Chemical
University of California/San Diego	Pioneer
University of Connecticut	ProdiGene
University of Florida	Research for Hire
University of Georgia	Shoffner Farm Research, Inc.
University of Hawaii	Stine Biotechnology
University of Idaho	Syngenta
University of Illinois	Targeted Growth Inc.
University of Kentucky	United Agri Products
University of Minnesota	Ventria Bioscience
University of Missouri	
University of Nebraska/Lincoln	
University of Wisconsin	
University of Wisconsin/Madison	
Washington State University	
Virginia Tech	

Source: USDA. APHIS
*Eight biotech crops (corn, soybeans, cotton, rapeseed/canola, wheat, potato, rice, sugar beets)

- The Minneapolis Federal Reserve District Bank estimated the number of R&D firms in engineering, physical and life sciences in Minnesota at 178 in 2001, followed by Wisconsin with 128, Montana with 53, North Dakota with 20 and South Dakota with 17, or 396 in the five states. Employment in these firms grew at least 50 percent from 1998 to 2002 in Minnesota and Wisconsin, adding 1,000 jobs each.

- There is reason to believe that many estimates of plant biotech activity have been substantially understated, even by industry spokesmen. The Biotechnology Industry Organization (BIO), for example, identified only 64 biotech companies in the Midwest. Yet a 2003 survey of Minnesota firms by the state's Department of Employment and Economic Development found 170 firms in scientific biotech in Minnesota alone, of which two in five were in the agricultural and industrial sectors.

- The Wisconsin Association for Biomedical Research and Education (WABRE) in 2001 identified almost 200 Wisconsin bioscience companies, including 56 in the agricultural sector. These companies employed some 21,000 workers, with an additional 5,000 employed in R&D at Wisconsin universities and laboratories. WABRE estimated total industry activity at $5 billion, about 3 percent of gross state product.

- Bureau of Labor Statistics from the U.S. Department of Commerce's Occupational and Employment Survey (OES) were examined for evidence of plant biotech impacts. Plant biotech does not fit neatly into OES categories. We examined three U.S. sectors: crop services (with 128,500 workers in 2001); agricultural chemicals (46,490 workers in 2001); and farm products — raw materials (97,180 in 2001). Apart from these sectors, plant biotech firms employ many of the same skilled workers as other sectors of the economy (managers, computer programmers, legal advisors, etc.).

- What makes plant biotech different is the reliance on life science workers, including food scientists, microbiologists, biochemists and biophysicists. These workers typically require advanced degrees and training, and receive above-average wages. In 2001, the OES estimated 13,470 agricultural and food scientists (AFS) alone employed in public and private institutions with an average salary of $52,310 a year, more than one and one-half times the U.S. average of $34,020.

• The states which have been the most rapid adopters of biotech corn and soybeans up to 2003 were compared with the size of the AFS job category. Those states with the highest levels of biotech crop adoption had more AFS jobs per 100,000 in 2003 than states with lower levels. (See Figure 10.)

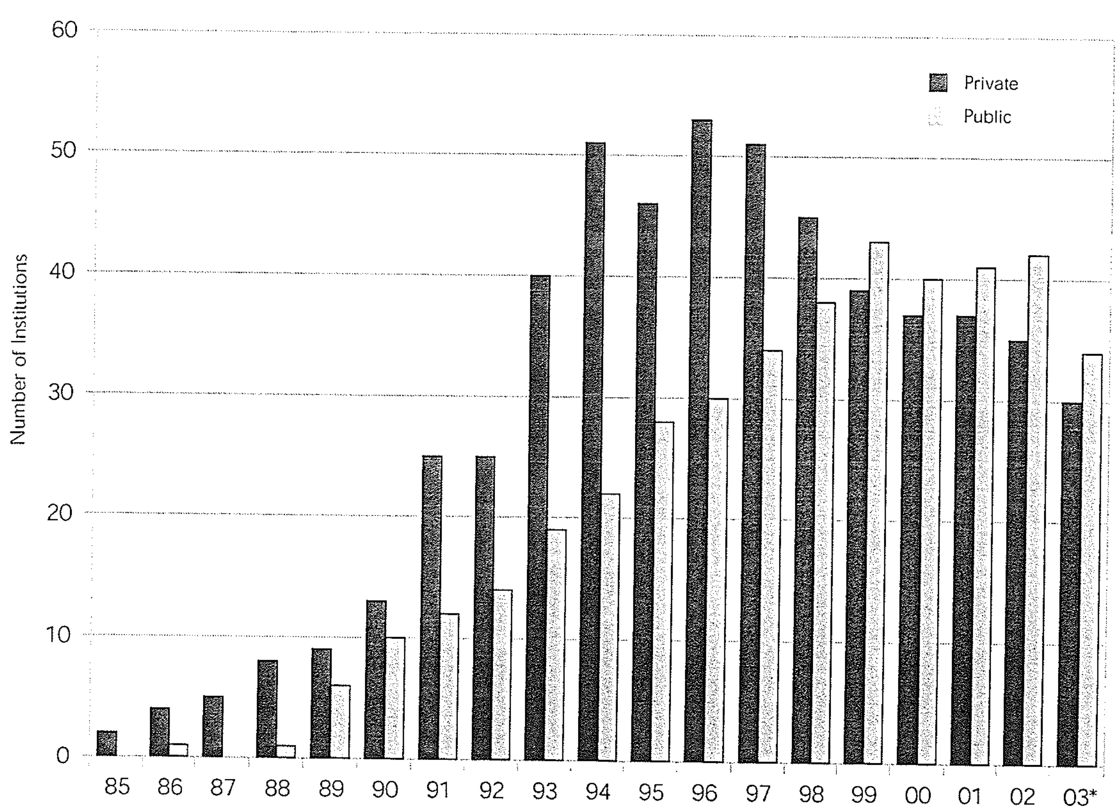
• The distribution of wages in the AFS sector showed that overall, AFS workers in the states with the highest levels of biotech plant adoption made between 1.5 and 2 times the average wage. These wages exceeded averages throughout the career life cycle.

• The states' role in value creation shows that commercial plantings of biotech crops have benefited a wide range of individual state economies. These include especially the corn and soybean producing states of Iowa, Illinois, Minnesota, Nebraska, Indiana, South Dakota, Missouri, North Dakota, Ohio, Wisconsin and Michigan. They also include cotton producing states such as Arkansas, Mississippi, Texas, California, Georgia and others.

• On the research side, state land grant universities and the U.S. Department of Agriculture have been active in plant biotech research. Among the research institutions involved are Universities in Arizona, California, Colorado, Connecticut, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Missouri, Montana, Nebraska, New Jersey, New York, North Carolina, North Dakota, Ohio, Oregon, Pennsylvania, Texas, Virginia, Washington and Wisconsin.

• When private and public institutions involved in field test permits are compared over time as shown in Figure 9, two pictures emerge: first, there has been steady progress in public sector research through the years. Second, it suggests private sector growth expanded rapidly in the early 1990s;

Figure 9
Number of Private and Public Institutions Granted APHIS Field Test Permits, 1985-2003



*Data for 2003 only includes the first 8 months.

however, the apparent decline in activity since 1996 is likely due to rapid consolidation of firms, leading to fewer private company filings.

Future Directions for Plant Biotechnology

• In conclusion, plant biotech and its future is of growing importance to producers, to the input supply industry, to private research and development investors, to educational and research institutions, to the federal government and increasingly to consumers.

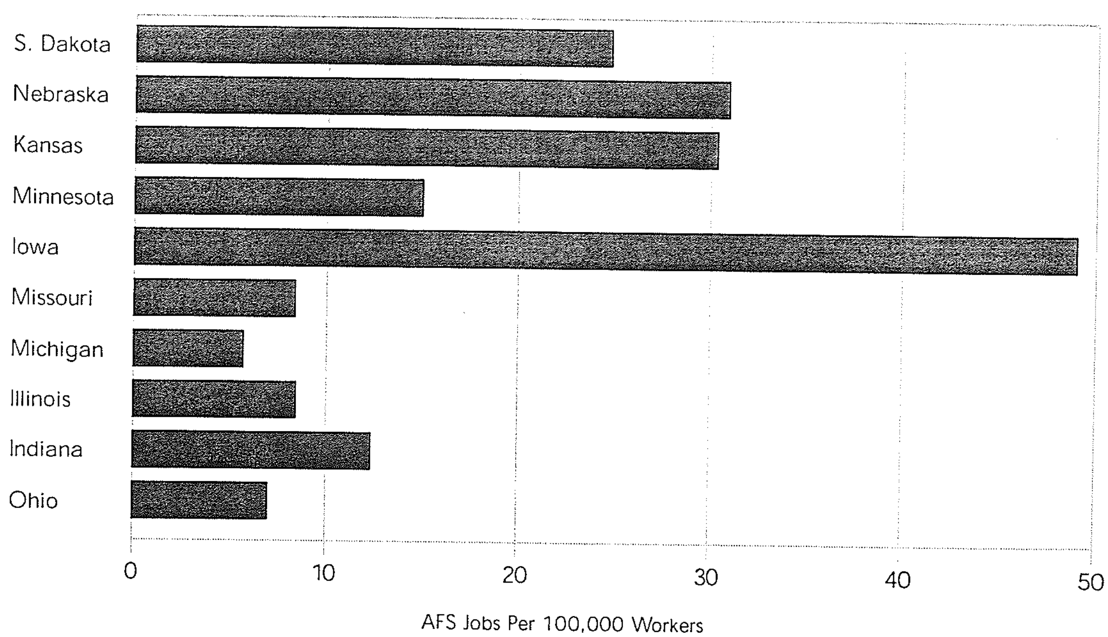
• For producers, valuable benefits conferred by plant biotech since commercial introduction in 1996 reached over $20 billion in 2002. In addition to direct improvements in profits, biotech varieties offer management efficiencies worth almost 65 percent more in economic benefits in some cases. Multiplied times the growing number of acres in biotech varieties nationally, these are significant contributions to farm income, especially in the Corn and Cotton Belt states.

• In the input supply industry, the introduction of biotech varieties has forced changes in the "bundles" of crop protection products, seeds and fertilizers sold to farmers, and promoted rapid consolidation of chemical and seed companies. Biotech varieties have given new impetus to precision agriculture, and offer traits that will yield social rewards not only for productivity but resource conservation and environmental improvements.

• Investors find that high investments are matched by high returns, but that long lags intervene between costs and benefits. These long lags mean that only companies able to commit resources over extended periods will dominate the R&D process. In general, these are larger, well-capitalized firms. Venture capitalists with shorter time horizons will need to find start-ups able to attach themselves to the R&D process of larger companies.

• Public sector R&D will remain important due to the leads and lags in the agricultural research process. Activity will continue to grow in the life sciences as public institutions remain repositories of knowledge worth hundreds of billions of dollars a year. The erosion of funding for land grants and state and federal budget deficits will therefore have negative consequences for the entire plant biotech sector. New directions must maximize the complementarity between private and public science.

Figure 10
Highest Ranking Plant (Corn and Soybean) Biotech Adopting States and Agricultural and Food Scientists (AFS) per 100,000 — 2003



Source: Bureau of Labor Statistics, U.S. Department of Commerce

- The federal government's role will become even more important as the regulatory scope of plant biotech requires oversight by not only USDA and its sub-agencies, but FDA, EPA and other agencies such as the Small Business Administration or the export-promotion arms of the Department of Commerce. NSF and NIH will also play key roles.

- The ultimate arbiter of market growth and development is the consumer. As consumer confidence grows, it will feed the demand for new biotech varieties, support those who supply them, and build a base for public investments in the plant biotech research base, resulting in more jobs at higher wages.

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DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20250

December 21 2004

Mr. Gus Douglass Commissioner
The National Association of State Departments of Agriculture
1156 15th Street, N.W.
Suite 1020
Washington, D.C. 20005-1711

Dear Commissioner Douglass:

Thank you for your letter on October 15,2004, on behalf of the National Association of State Departments of Agriculture (NASDA) concerning organic agriculture and biotechnological agricultural methods, and for NASDA's statement supporting diversity in agriculture.

Your letter raised several questions that have been raised by and to NASDA members regarding the implications of genetically-modified, genetically-engineered, or biotech crops and seeds on certified organic production and handling operations. Let me address each of the issues raised in your letter. Where applicable, citations from our regulations and its preamble (7 CFR Part 205), including page numbers, are included.

Issue: If a producer adheres to all aspects of the National Organic Program (NOP), including never utilizing biotech-derived seeds, but a certifying agent tests and detects the presence of biotech-derived material in the crop, is that crop's status determined to be no longer "certified organic?" And, if so, what in the NOP supports this conclusion?

Reply: It is particularly important to remember that organic standards are process based. Certifying agents attest to the ability of organic operations to follow a set of production standards and practices that meet the requirements of the Act and the regulations. This regulation prohibits the use of excluded methods in organic operations (§205.2-Terms defined, and §205.105-Allowed and prohibited substances, methods, and ingredients in organic production and handling). The presence of a detectable residue of a product of excluded methods alone does not necessarily constitute a violation of this regulation. As long as an organic

operation has not used excluded methods and takes reasonable steps to avoid contact with the products of excluded methods as detailed in their approved organic system plan, the unintentional presence of the products of excluded methods will not affect the status of the organic operation. As to the status of the commodity, USDA's position is that this is left to the buyer and seller to resolve in the marketplace through their contractual relationship. (See page 80556 of the preamble, "Applicability-Clarifications; (1) "Genetic drift").

Issue: You refer to a section on the NOP web site commonly known as FAQs, or frequently asked questions, that address the presence of a detectable residue of a product of excluded methods. You ask if insufficient buffers or barriers that result in unintended contact with a product of genetic modification would threaten the farm's certification or use of the field for the production of organic crops. You also ask if an organic producer or handler is found to have not implemented measures necessary to prevent commingling of organic and non-organic products, would that threaten the certification of the producer or handler?

Reply: In order to become a certified organic operation, a producer must submit an Organic System Plan (plan) to a USDA-accredited certifying agent for approval. That plan must include, among other things, evidence that sufficient buffer zones have been incorporated into the operation to ensure the integrity of the organic crop operation. The certifying agent must not approve a plan that does not provide evidence of sound measures taken to ensure the integrity of the organic crop operation, including buffer zones and other steps to prevent commingling with unapproved non-organic materials or conventional crops. If a producer does not adhere to such preventive measures, the certifying agent is expected to denote such failure as a noncompliance and take appropriate measures toward correction by the producer. Inadequate buffer zones should not be approved in the first place and failure to comply with approved buffer zones constitutes a noncompliance with the approved organic system plan. (See the preamble, page 80558, on Subpart C-General Requirements, which describe what must be contained in an organic system plan, and §205.2 under terms defined -Buffer zone.)

However, even when all precautions have been taken, and an approved buffer zone fails to provide the protection that both the operator and the certifying agent reasonably expected, certifying agents must not "retroactively" punish the producer by an enforcement action or "de-certify" the organic crop. The appropriate action to take in this case is to re-evaluate the buffer zone and other preventive measures in the plan to ensure improved integrity and performance in the future. As to the status of the commodity, USDA's position is that this is left

to the buyer and seller to resolve in the marketplace through their contractual relationship. (See page 80556 of the preamble, "Applicability-Clarifications; (1) "Genetic drift").

Issue: You ask if a certified organic operation that refrains from intentional use of biotech seeds has ever lost certification for the inadvertent presence of biotech material in its crop, and if so, how many and under what circumstances did the loss of certification occur?

Reply: No accredited certifying agent has reported to us that certification has been lost due to adventitious presence of biotech material. In one instance, a producer admitted to deliberately planting GM-corn seed and representing the crop as organic corn, for which we took enforcement action and revoked the organic certification.

Issue: You ask if food labels stating "GM, GE, or GMO-free" are part of the National Organic Standards?

Reply: They are not. Truthful labeling is embodied in the National Organic Standards, as supported by USDA's Food Safety and Inspection Service (FSIS), the Food and Drug Administration (FDA), and the Federal Trade Commission (FTC) -the agencies with respective jurisdiction over truthful labeling laws. In the preamble of the National Organic final regulations, we stated that organic is not synonymous with "GM -free," when we said: "These phrases may...be used as additional, eco-labels, provided they are truthful statements...[but] they are not permitted as replacements for the term 'organic.'" (See page 80586 of the preamble, under "Labeling-Changes Requested But Not Made: (7) Use of Other Terms as Synonymous for "organic").

Issue: You also state that it would be helpful to confirm "the role of a marketing order of this kind, e.g., that the order is intended to control the activities of those who voluntarily opt in to the program," and whether a marketing order can be used to control the production activities of other growers who do not choose to participate in the program.

Reply: First, the organic program is not a marketing order, in the traditional sense of marketing orders administered by the Agricultural Marketing Service for fruits and vegetables and for dairy producers. The NOP is, as you correctly point out, a voluntary program -that is, producers who wish to become a certified organic operation can do so by adhering to all of the regulatory requirements and successfully achieving certification status by a USDA-accredited certifying agent. But the NOP confers no rights on such producers to control the activities of non-

organic producers. In fact, "split operations" are permitted under the NOP. That is, a producer may have part of an operation that is certified organic, and the remainder of the operation is a conventional agricultural operation. In that case, the regulations related to commingling of organic and non-organic operations and products discussed above apply to that split operation.

Issue: You ask if there is a working definition of the word "contamination" within the NOP, noting that the word "contamination" is used frequently in the final regulations, and if all products of genetic modification are considered "prohibited substances" as defined in the final regulations? And, what actions are authorized or required when organic crops or products are found to contain unintended or inadvertent genetically modified hybrids or other genetically modified substances?

Reply: There is no definition in the final regulations of the National Organic Standards for the word "contamination," even though, as you point out, it is mentioned frequently. By our count, "contamination" is mentioned nearly 50 times in the regulations. All genetically-modified practices or products are indeed considered prohibited, as cited in 205.105, the paragraph that describes "excluded methods." Please refer back to the above issue when considering the adventitious presence of a genetically-modified or genetically-engineered substance. Such adventitious presence does not affect the status of the certified operation and does *not* necessarily result in loss of organic status for the organic product, provided it was produced in adherence with all of the organic requirements under 7 CFR 205. Again, the action regarding the final product's status in this case is left to the determination by the buyer and seller of the product.

Contamination by a prohibited substance, when mandated by a government body, however, would result in loss of organic status for the product, even when all other regulations had been followed. In the case of an emergency spray program, for example, if the spray is a prohibited substance but is mandated by a State or Federal program, the crop's organic status is lost and that crop must be diverted for sale in the conventional market. Neither the operation nor the land's organic status is altered by an emergency spray program, however. (See §205.672 Emergency pest or disease treatment.)

I appreciate this opportunity to respond to these issues and to echo the statement of NASDA members -USDA supports and promotes all methods and segments of

agriculture and our goal is to ensure that farmers are successful in meeting market demand, whether they choose to plant biotech, conventional, or organic crops. Thank you again for writing about these important issues.

Bill Hawks
Under Secretary
Marketing and Regulatory Programs

October 15, 2004

The Honorable Ann Veneman
Secretary
United States Department of Agriculture
1400 Independence Avenue, S.W.
Washington, D.C. 20250

Dear Secretary Veneman:

Thank you very much for attending the annual National Association of State Departments of Agriculture (NASDA) meeting in St. Paul, MN on September 29, 2004. The meeting benefited from your participation. We appreciate your commitment to a partnership with NASDA members and your long-term support of the NASDA organization.

NASDA members also appreciate your efforts and assistance in implementing the National Organic Program (NOP) within the Agriculture Marketing Service Agency of USDA. An important aspect of the National Organic Standards (NOS) was discussed at our annual meeting—that of the effect that unintended traces of biotech crops identified in certified organic crops has on a grower's organic certification. We understand the federal policy that the rule conveys to be that *unintended traces will not necessarily affect a grower's certification.* We also recognize that the agency's website does mention this issue in this context in both the Preamble and the Frequently Asked Questions (FAQs).

Be that as it may, our members are experiencing greater than ever levels of confusion among producers, local governments and consumers when dealing with this issue. Our members are, in fact, increasingly finding that—what we believe to be an erroneous interpretation of the NOP—is being used to justify positions in favor of prohibiting biotech crops at state and local levels. This interpretation is frequently being portrayed as national policy, i. e., that grower certification *will* be affected if unintended traces are found in an organic grower's crop. This confusion is evidenced by references on organic websites, in the media and in conversations with organic producers and as a driver of some state and local legislative efforts to restrict biotechnology.

At our winter meeting this year, NASDA adopted a policy statement in support of organic agriculture. As part of that statement, NASDA called for full and consistent implementation and enforcement of NOP production and handling standards, efforts to increase the economic growth of the organic industry with marketing assistance, increasing activity in organic research and education and collecting statistics on organic production and market growth. We strongly support organic agriculture and know that we must help to find ways for producers to coexist. In that light, we know we also must portray the tenets and the intent of the national program accurately.

As you know, NASDA members are often called upon to provide guidance on how federal agricultural policy affects state issues. It is important for NASDA members to be armed with all the facts—and substantiation of those facts—to adequately respond. As a result, we request written clarification on the following:

- Official testimony by organic growers before state legislative agriculture committees regarding "genetic drift" has caused confusion with state legislators about what "drift" means to the status of organic crops covered under the NOP. If a producer adheres to all aspects of the NOP, including never utilizing biotech-derived seeds, but a certifying agent tests and detects the presence of biotech-derived material in his/her crop, is that crop's status determined to be no longer "certified organic?" What in the NOP supports this conclusion?

  - Since the FAQ section of the NOP website states that "The presence of a detectable residue of a product of excluded methods [e. g., GM products] alone does not necessarily constitute a violation...", can you elaborate on the following:

    a. If the organic producer is found to have insufficient buffers or barriers in place to prevent the unintended application of a product of genetic modification to the crop or contact with a product of genetic modification applied to adjoining land, would that threaten the farm's certification or use of the particular field for production of organic crops?

    b. If an organic producer or handler is found not to have implemented measures necessary to prevent the commingling of organic and non-organic products and protect organic products from contact with genetically modified products, would that threaten the producer or handler's certification?

- State legislative testimony, media articles and dialogue in the grower community suggest that organic farms have lost their certification due to the presence of biotech crop material in their organic crop. NASS's 2002 statistics show there were nearly 12,000 certified organic farms in the United States. Has a certified organic operation that refrains from intentional use of biotech seeds ever lost certification for the inadvertent presence of biotech material in its crop? If so, it would be helpful to know how many and what were the circumstances?

- Organic growers have made claims to legislators and agriculture policy leaders that they will lose buyers of their organic crop if there is any biotech-derived material in their crop. Some food producers have chosen to avoid ingredients that have come from biotech improved crops. Their food labels may state the product is "GM, GE, or GMO-free" [1]. Are these marketing claims a part of the Organic Standards? It would also be helpful if you could confirm the role of a marketing order of this kind, e. g., that the order is intended to control the activities of those who voluntarily opt in to the program in contrast to a traditional regulatory program that sets standards that all growers must adhere to, regardless of the type of growers they may be. Can a marketing order be used to control the production activities of other growers who do not choose to participate in the program?

- There is widespread use of the term "contamination" as it pertains to the inadvertent presence of biotech material in an organic crop. While "contamination" is not defined in the act or in the agency's rules, it is used several times in the Standards. Is there a working definition of "contamination" within the NOP? Are all products of genetic modification, the

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1 GM (genetically modified), GE (genetically engineered), and GMO (genetically modified organism)

use of which in any aspect of organic production or handling is prohibited, considered "prohibited substances" as defined in the National Organic Standards? In addition, what actions, if any, are authorized and/or required when organic crops or products are found to contain unintended/inadvertent genetically modified hybrids or any other genetically modified substances?

As you know, NASDA members support and promote all methods and segments of agriculture and our goal is to ensure that farmers—whether they choose to plant biotech, conventional or organic crops—are successful in meeting market demand. Because both organic and biotech crop production are steadily increasing, we believe that continued confusion surrounding biotech crops and the NOP unnecessarily pits grower against grower. We believe your prompt response to these questions will aid us to focus on the value of peaceful coexistence between and among producers. Clarification of these issues will be helpful to state and local agriculture officials, accredited organic certifying agents, locally elected officials, farmers in our respective states and consumers who often call upon us to answer questions regarding the effects of the National Organic Program in our localities. In addition, we are willing to work with you in order to identify the best ways to clarify these issues and disseminate the information.

Sincerely,

Original/signed/sent on letterhead

Gus Douglass
Commissioner
West Virginia Department of Agriculture
Chair
NASDA's Animal and Plant Industries Committee

cc: Bill Hawks, Undersecretary, Marketing and Regulatory Programs
A.J. Yates, Administrator, Agricultural Marketing Service

A-1275

Suggested Best Management Practices

for the Coexistence of

Organic, Biotech and Conventional

CROP PRODUCTION SYSTEMS

North Dakota has a diverse agriculture with differing production systems and markets. It is important that those involved in agriculture work together to preserve and enhance each person's chosen production system and markets.

The Coexistence Working Group was formed to identify and address issues facing agriculture in North Dakota. Membership in the group consisted of biotech, conventional, identity-preserved and organic farmers; biotech companies; organic certification organizations and groups; North Dakota Department of Agriculture; North Dakota State Seed Department; NDSU Foundation Seedstocks Project; NDSU Department of Plant Sciences; NDSU Agricultural Experiment Station; and the NDSU Extension Service. Participants were carefully chosen so leaders from each group were involved in the discussion.

History

North Dakota State University was contacted by the Northern Plains Sustainable Agriculture Society (NPSAS) in spring 2001. NPSAS was concerned about the ability of organic and identity-preserved producers having access to seed free of any transgenic genes. Those in attendance represented NDSU, state government and the organic community. After discussing the issues, it was decided to have another meeting in the fall.

It was also stated that more stakeholders should be involved. For the next meeting, the group decided to bring in conventional, biotech and identity-preserved farmers and representatives of biotech firms.

Procedure

The Coexistence Working Group would develop Best Management Practices (BMPs). The group was divided into three subgroups to come up with the recommendations. Individual group members were also able to propose BMPs. The proposed BMPs were discussed and voted on, with the minority opinion stated on each BMP. The findings of the group would then be printed and distributed to interested parties in North Dakota.

A North Central Sustainable Agriculture Research and Education Grant was applied for and received. Additional funding was provided by Monsanto. With the funds in place, the Coexistence Working Group was founded with Brad Brummond as grant coordinator. The first meeting focused on identifying issues. The second and third meetings were used to gather and present material on these issues.

OBJECTIVES

- Implementation of practices and protections to ensure purity and accessibility of the genetic resource base.
- Ensure integrity and marketability within the food system.

NDSU
Extension Service
North Dakota State University
NOVEMBER 2004

Suggested Best Management Practices for the Coexistence of Organic, Biotech and Conventional Crop Production Systems

Compiled and voted on by Coexistence Working Group* in December 2003. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of USDA.

*Ken Bertsch, Ab Basu, Greg Daws, Ken Grafton, Richard Gross, Wallie Hardie, Duane Hauck, Janet Jacobson, Dave Nelson, Robert Sinner, Richard Schlosser, Roger Weinlaeder, Albert Schneiter plus proxy for Dale Williams, Theresa Podoll plus proxy for Annie Kirschenmann and Greg Wandrey plus proxy for Luke Bozeman.

The BMPs developed by the CWG are not intended to advocate the development or implementation of legislative or regulatory policies. BMPs may not represent the opinions of every member of the group. Dissenting opinions are represented in the minority reports.

Liability

Who will be responsible for the economic damages caused by the unintended presence* of genetic material?

(*Unintended presence: The presence of seed, genes, transgenic event or foreign matter in a variety or crop other than the one for which it was intended. Causes of unintended presence include physical mixing (i.e., commingling of seed) and to a lesser extent, pollen drift.)

BMP 1: Liability of Research and Development of Regulated Materials

Passed 9-8

Rationale

When liability becomes an issue, regulation compliance will be an important factor. Compliance should provide assurance that new technologies are properly managed through the research and development process.

Majority Recommendation

Researchers and developers of regulated genetic material must follow the established federal and state regulations as minimum standards to maintain purity and identity.

Minority Opinion

The protocols and regulations in place may not be adequate to provide containment of the technology in question.

Researchers and developers of regulated genetic material must follow established federal and state regulations. That's the law! They must also recognize that established federal and state regulations are minimum standards. However, meeting those minimum standards in no way insures containment. Placing this BMP under the heading of liability implies that meeting a minimum standard somehow limits liability. Meeting minimum standards does not ensure prevention of harm to stakeholders and, therefore, cannot insulate corporations or land-grant institutions from liability when contracting to do transgenic research.

There are risks inherent to open-air field trials of regulated transgenic material. Any release or escape of this material would be illegal and have a great potential for harm. No requirement for a state-of-the-art DNA test for the presence of a gene event greatly increases the risks. This test is necessary to scientifically investigate and validate the sufficiency of the isolation and containment protocols. Conducting open-air research without the ability to verify the adequacy of their protocols is not sound science nor is it defensible in the face of liability. The lack of this requirement indicates the insufficiency of current regulatory oversight.

Sources

1. *USDA Animal Plant Health Inspection Service*
2. *North Dakota Department of Agriculture*
3. *North Dakota State University*

BMP 2: Educational Responsibilities

Passed 13-3

Rationale

Education is critical for the proper stewardship of new technologies.

Majority Recommendation

Each party selling or marketing agricultural seed and resulting commodities should be responsible for product-stewardship education and contract obligations at each point of sale. Communicating the effective and responsible use of relative technology should be the responsibility of land-grant universities and technology providers.

Minority Opinion

None

BMP 3: Contractual and Merchandising Obligations

Passed 14-2

Rationale

All growers and handlers should be aware of the requirements and risks of contracts they enter into and the ramifications those requirements might have on their production and operating plans.

Majority Recommendation

Producers must know, understand and follow the market contracts they enter into, as well as any regulatory requirements and testing protocols for the crops that are produced. Handlers must also know, understand and follow terms of the market contracts, market channeling requirements and any testing protocols for the crops they handle.

Minority Opinion

None

Sources

1. *Farmers Legal Action Group, "Potential for Legal Liability from GMOs"*

BMP 4: Review of Insurance Policies

Passed 15-1

Rationale

All stakeholders need to know and understand their risks. Insurance industry officials are considering developing an exclusion for unintended presence and resulting damages or liability in farm-owner policies.

Majority Recommendation

All stakeholders should review their insurance and bond coverage with respect to provisions related to coverage for losses or damages resulting from unintended presence.

Minority Opinion

None

Sources

1. *Farmers Legal Action Group: "Potential Legal Liability from GMOs"*
2. *American Corporation GMO (Genetically Modified Organism) Crop Exclusion Center, Mutual Insurance: "What Are the Insurance Coverage Implications of GE Agriculture/Food Risk?"*

Land-Grant Research Funding

What is the land-grant mission and what impact do private research contracts have on it?

No BMP proposed.

Segregation

This centers on how products could be separated within the handling and transportation systems and what costs would be associated with maintaining separate systems.

BMP 5: Producer Segregation Practices

Passed 16-0

Rationale

Segregation is essential for coexistence, therefore practices and information that maximize crop and product purity should be utilized where possible.

Majority Recommendation

Producers need to utilize practices and information that help maximize crop purity and segregation. This includes knowing as much as possible about your seeds, seed standards, cropping history and production practices, crop characteristics and recommended isolation distances, your farm, your neighbors' crops and production systems, your equipment, the crop you harvest, sampling and testing protocols for quality characteristics required by your market, postharvest storage, transport, keeping records, risks and rewards.

Minority Opinion

None

Sources

1. *Riddle, James A. "A Plan for Co-existence: Best Management Practices for Producers of Biotech Crops"*
2. *"Combine Clean-Out Procedures for Identity Preserved Grain," Iowa State University, Iowa Quality Grains Initiative, Iowa State University (ISU) Extension and the Iowa Agriculture & Home Economics Experiment Station*
3. *"Planter Clean-Out Procedures for Corn and Soybeans," Iowa State University - Pioneer Hi-Bred International Inc.*
4. *Fehr, Walter R. "Strategies for the Coexistence of GMO, Non-GMO, and Organic Crop Production"*
5. *Martens, Mary-Howell R. "Strategies to Minimize Genetic Contamination on Organic Farms"*
6. *Riddle, James A. "10 Strategies to Minimize Risks of GMO Contamination"*

BMP 6: Segregation (Farmer Clean Out)

Passed 15-0-1

Rationale

Good segregation practices are essential to coexistence.

Majority Recommendation

All producers and truckers should carefully inspect and clean trucks and trailers after crops have been unloaded. This includes tarps and trailer covers. Recommend the keeping of records to document the cleaning of transport units.

Minority Opinion

None

Sources

1. *Riddle, James A. "Plan for Co-existence: Best Management Practices for Producers of Biotech Crops"*

Tolerances

Do we or do we not want tolerances? If we decide we want tolerances, at what level? We realize that zero tolerance would be very difficult, if not impossible, in commercial production. How would inclusion of tolerances affect markets? Is no detectable level in our seed supplies realistic?

For Comment Purposes Only

This is not a Best Management Practice. The Coexistence Working Group felt the marketplace ultimately makes the decision. For that reason, the issue was not addressed.

We must remember that coexistence is a journey, not a destination

BMP 7: Buyers Set Tolerances (Thresholds) For the Commercial Markets

Passed 16-0

Rationale

Consumer purchase preference varies.

Majority Recommendation

Tolerances (thresholds) of government-approved transgenic traits are a function of the marketplace and should not be set by a political subdivision or legislation. The marketplace, represented by the purchasing entity, will determine the acceptable level (tolerances) of unintended presence.

Minority Opinion

None

Seed Certification Standards

This relates to the last question under tolerances: Is no detectable level in our seed supplies realistic? What standards and protocols will the Association of Official Seed Certifying Agencies (AOSCA), seed trade associations and state foundation and certified seed programs adopt, and how do those standards impact the seed industry and markets?

BMP 8: Do Not Set Seed Certification Standards for the Presence of Transgenic Material in Nontransgenic Seed

Passed 9-8

Rationale

- The marketplace determines thresholds and standards for seed and product quality characteristics, including the level of transgenic material in nontransgenic seed.
- Seed and product quality characteristics needed by the marketplace are extremely diverse and depend on the specifications set by producers and buyers.
- Setting standards for the presence of transgenic material would artificially affect the market-driven specifications and may eliminate from the market seed that is perfectly acceptable to producers and buyers.
- Thresholds and standards established for allowable percentage of transgenic material in certain geographic areas around the world have been politically based, rather than being based on science and safety assessments.

Majority Recommendation

Recommend that the North Dakota State Seed Department not develop seed certification standards for the presence of transgenic material allowed in public classes of nontransgenic seed.

Minority Report

Without standards and enforcement of the unintended presence of transgenic material in seed lots, pedigreed seed producers, farmers and markets will have little hope of avoiding or minimizing the occurrence of GM traits on their land or in their crops. This conclusion is supported by University of Manitoba scientific research.

The results indicate that the pedigreed canola seed production system in western Canada is cross-contaminated at a high level.

The pedigreed seed production system can be considered a stringent segregation/identity preservation system. The results also indicate that this stringent segregation system does not result in the genetic purity of pedigreed canola seed lots in western Canada. Furthermore, a successful segregation/identity preservation system requires agreed-upon tolerances for contaminants and enforcement of the standards through frequent testing and discarding of out-of-tolerance seed or grain lots.

The commercialization of glyphosate resistant wheat in western Canada is being contemplated, possibly initially under an identity preservation protocol. It can be predicted that the extent of glyphosate resistance trait contamination in pedigreed conventional wheat seed lots and commercial grain lots will eventually be similar to or greater than the situation currently in canola.

Sources:

1. *Canadian Seed Growers Association, 2002*
2. *Friesen, Lyle F., Alison G. Nelson, and Rene C. Van Acker. 2003 "Evidence of Contamination of Pedigreed Canola (Brassica napus) Seedlots in Western Canada with Genetically Engineered Herbicide Resistance Traits." Agronomy Journal 95: 1342-1347*

BMP 9: Publicizing the Process for Providing Input into Seed Certification Standards

Passed 11-5

Rationale

Publicizing the process for input into seed certification standards will increase the awareness of individuals and increase input to the State Seed Department from a broad representation of interested parties.

Majority Recommendation

Recommend the North Dakota State Seed Department publicize the already-established process for interested parties to provide input into the seed certification standards. This includes recommendations for seed quality characteristics for unintended presence in lots of nontransgenic foundation, registered and certified seed.

Note: The marketplace will ultimately determine the product-quality characteristics and specifications required in seed and grain.

Minority Opinion

None

BMP 10: Pre-plant Test Seed

Passed 16-0

Rationale

The quality of seed, including the genetic purity and disease or physical contamination, has traditionally been determined under field and lab inspection standards. This applies to both "certified" and "quality-assured" seed sources. These inspections have primarily been accomplished by visual means. The evolution and development of specific genetic traits in seed sources require laboratory testing to determine presence or absence.

Unless written into a seed standard, the presence of a GM trait is not considered in seed certification. Currently, unless specifically requested by the grower or customer, the presence of GM traits in conventional varieties is implied by the variety name. The responsibility for determining the presence of GM traits in conventional seed sources is arguable. Today's industry standard suggests that, if there is a concern of unintended presence, the purchaser should pre-plant test the seed.

Majority Recommendation

If there is a concern of unintended presence, the purchaser should pre-plant test the seed.

Minority Opinion

None

Germ Plasm Purity

What are the land-grant polices relating to the ownership and use of public genetics by private corporations? What is the cold storage reliability of public varieties? How is the genetic integrity of public varieties protected? Is there a need to have dual-breeding systems at land-grant institutions and if so, who finances it?

BMP 11: Maintaining Breeder and Foundation Seed Stock Purity

Passed 11-4

Rationale

Germ plasm-, breeder-, and foundation-seed stocks free from unintended presence must be maintained to provide producers with viable production options. Segregation is essential for coexistence, therefore practices that maximize crop and product purity should be utilized.

Majority Recommendation

North Dakota State University must strictly isolate the planting and handling of transgenic crops from sites where breeder- and foundation-seed stocks are grown, conditioned or stored and implement a state-of-the-art testing regimen for unintended presence in breeder and foundation seed stocks.

Minority Opinion

None

Sources:

1. *Fehr, Walter R. "Strategies for the Coexistence of GMO, Non-GMO, and Organic Crop Production"*
2. *North Dakota Agricultural Experiment Station. "Seedstocks Policies and Production Handbook"*
3. *NDSU Extension Service. "North Dakota County Crop Improvement Associations Seed Increase Program." Publication A-520, revised September 2003*

Opportunities/Consequences

This relates to the cost/benefits of transgenic products and traits and effects on non-transgenic markets. What can be gained or lost?

No BMP proposed.

Neighbor Relations

How can growers work together to protect each other's markets and limit movement of unwanted genetic material?

BMP 12: Neighbor Relations and Communication

Passed 16-0

Rationale

Proactive, clear communication and cooperation among neighbors is a significant factor in maximizing production options and marketing opportunities for all parties.

Majority Recommendation

We recommend that growers make reasonable attempts to communicate their production intentions to their neighbors prior to planting and to confirm actual planting. We recommend that neighbors communicate important information about the production practices to be used and the best management practices being utilized to promote the coexistence of all crop production systems.

Minority Opinion

None

Sources:

1. *Riddle, James A. "A Plan for Co-existence: Best Management Practices for Producers of Biotech Crops"*
2. *Riddle, James A. "10 Strategies to Minimize Risks of GMO Contamination"*
3. *Fehr, Walter R. "Strategies for the Coexistence of GMO, Non-GMO, and Organic Crop Production"*

Controls on Research

Who controls research and the assessment process used in commercialization of biotech crops? What are the protocols for research on the land-grant-institutional level and who is responsible for oversight?

No BMP proposed.

Consumer Concerns

What is the consumer and market acceptance of biotech crops? This also deals with labeling requirements, testing and export markets.

BMP 13: Education of Consumers

Passed 16-0

Rationale

Informed decision making is basic to our society and provides a logical approach to dealing with public issues. Society needs access to unbiased information to make informed decisions. The Cooperative Extension Service historically has been a trusted provider of this type of information.

Majority Recommendation

The NDSU Extension Service will develop an educational brochure and a Web site designed to educate the public on how foods (crops) are produced under biotech, nonbiotech and organic crop production systems. The goal is to provide consumers with unbiased information on the various food production systems so they can make an educated choice. Representatives would make recommendations to the authors for consideration. Points of disagreement would be mediated by the Coexistence Working Group. The finished product may be both printed and Web-based.

Minority Opinion

NA

Conclusion

The Best Management Practices (BMPs) are a place to start in fostering coexistence in North Dakota agriculture. We must all do our part to ensure a place for different types of production systems and access to markets in North Dakota.

Some would say that these Best Management Practices do not go far enough. We must remember that coexistence is a journey, not a destination. Adoption and implementation of these BMPs will help make coexistence possible. There is still more work to be done, but the process has started in North Dakota.

Acknowledgments

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Press release

Embargo: 10.00h, 16 October 2004

GM opponents' theory on co-existence "exaggerated" according to new report

Zaragossa, 14 October - Five key principles are all it takes to ensure the successful co-existence of GM, organic and conventional crops. This is according to a new research paper released today by PG Economics.

Co-existence is currently high on the agenda of opponents to GM technology who believe that GM crops cannot 'co-exist' along side their organic and conventional equivalents and are calling on EU governments to set up liability rules to protect non GM farmers from 'contamination'. The research paper "*Co-existence of GM and non GM crops: current experience and key principles*" – highlights fundamental flaws in many of their 'exaggerated' arguments.

According to the report, on-farm experience in North America and Spain since 1995 has demonstrated that through the application of sensible farm level practices (e.g. the separation of crops by space and time, good communication with neighbours and the use of good husbandry practices) successful co-existence between GM and non GM crops has been possible, and without government involvement.

Speaking in Zaragossa, Spain, Graham Brookes, author of the report said:

"Like all good farm management practice, the co-existence of different agricultural production systems requires mutual respect and shared responsibly by all parties including both GM and non GM growers. If you apply the five key principles outlined in the report and adapt these to local circumstances on a crop by crop basis, effective co-existence practices can be achieved."

The five key principles[1] are:

1. **Context**: Determine the relative commercial and agronomic importance of different crop production systems based on planted area, production and economic value.
2. **Consistency**: Producers should be consistent in dealing with the adventitious presence of **all** unwanted material, including GM, organic and conventional.
3. **Proportionality**: All co-existence measures established should be proportionate, non discriminatory and science-based.
4. **Equity (fairness):** Any economic liability provisions (that compensate non GM growers for adventitious presence of GM) should be equally applicable to GM growers for adventitious presence of non GM crops. No one sector should be able to veto another – access and choice works both ways
5. **Practicality**: All co-existence measures should be based on legal, practical and scientific realities.

Co-existence is based on the premise that farmers should be free to cultivate the crops of their choice using the production system they prefer whether they are GM, conventional or organic. Despite claims from opponents, co-existence is <u>not</u> a crop safety issue but one that relates solely to the production and marketing of crops approved for use.

ENDS

For further details contact **Graham Brookes**:
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e-mail: graham.brookes@pgeconomics.co.uk

The full paper is available on www.pgeconomics.co.uk

[1] The principles derive from four papers written by Brookes G & Barfoot P (2003 & 2004) on: co-existence case studies of arable crops in North America, the non GM and organic market context in Europe, arable crops in the UK and corn in Spain. All papers are available on

Co-existence of GM and non GM crops: current experience and key principles

Graham Brookes

PG Economics Ltd

Dorchester, UK
October 2004

Table of contents

Executive summary

What is co-existence?

Co-existence refers to the economic consequences resulting from adventitious presence of material from one crop in another and is related to the principle that farmers should be able to cultivate freely the crops of their choice using the production system they prefer (GM, conventional or organic). It is not therefore a product/crop safety issue but relates solely to the production and marketing of crops approved for use.

When is co-existence an issue relating to GM crops?

It becomes an issue only when there is a distinct, preferential demand for a crop grown without the use of GM technology. If there is no distinct, non GM demand, there is no (GM) co-existence issue.

Co-existence of different agricultural production systems is nothing new

Farm level practices (eg, separation of crops by space and time, communicating with neighbours, use of good husbandry, planting, harvest and storage practices) to enable successful co-existence have been practiced by many farmers (eg, seed producers and growers of specialist crops) for many years.

Commercial experience to date

The key findings of research into co-existence of GM and non GM crops in two distinct regions (North America and Spain) are:

1. GM crops have been, and continue to co-exist successfully with conventional and organic crops in North America (where GM crops account for the majority of plantings of important arable crops like soybeans, oilseed rape and maize) and Spain;
2. Claims by anti GM groups that GM and non GM crops cannot co-exist in North America or Spain are greatly exaggerated, given the on-farm experiences since 1995 and 1998 respectively;
3. The market has developed practical, proportionate and workable co-existence measures without government intervention. Where isolated instances of adventitious presence of GM material have been found in non GM or organic crops, and are reported to have resulted in economic losses, these have usually been caused by poor implementation of good co-existence practices (eg, poor segregation of crops in storage and transport, not using certified (and tested) seed). In addition, where necessary, some operators have implemented revised measures to further minimise the chances of adventitious presence occurring. For example, the seed industry has found very low levels of GM adventitious presence in non GM seed of some crops like maize. As a result of this, co-existence practices have been revised to reduce further chances of adventitious presence occurring (eg, by increasing separation distances for foundation level seed crops of maize).

Co-existence requires co-operation

Successful co-existence of different agricultural production systems requires mutual respect and shared responsibilities by all parties. Responsibility for implementation of co-existence measures should involve both GM and non GM growers implementing appropriate management practices.

There are five key principles to good co-existence practice:

1. **Context**: It is important to determine the relative commercial and agronomic importance of different crop production systems based on planted area, production

and economic value. These properties are important considerations when assessing the likelihood of adventitious presence of material from one production system affecting another and the potential economic impacts. Context is particularly important to the third principle of proportionality – see below

2. **Consistency**: Producers and those overseeing the integrity/purity of crops/derivatives should be consistent in their behaviour towards the adventitious presence of all unwanted material, including GM derived material. It is unrealistic to expect 100% purity for any crop/product and this is why thresholds are set for adventitious presence of unwanted material. These (thresholds) should be proportionate to the risks attached to the presence of the unwanted material:

    - for the adventitious presence of (unwanted) material that pose known health and safety risks (eg, mycotoxin levels in cereals), it is appropriate to operate to very low threshold levels (eg, the limit of reliable detection);
    - for adventitious presence of (unwanted) material that affect product integrity, purity, quality and functionality (eg, impurities, weed/plant material, seeds/grains of off types[1]), wider thresholds are appropriate. Whilst these (thresholds) vary by crop and use, they are typically set at levels between 1% and 5%[2].

    In respect of the adventitious presence of GM material (which has been given regulatory approval for use[3]) in non GM crops, the threshold set, by the EU's GM labelling legislation, at 0.9% falls into the second category referred to above.

    Against this background, there are notable inconsistencies in the practices of some organic certification bodies relating to the treatment of adventitious presence of GMOs compared to the treatment of adventitious presence of other excluded products (see section 7.2).

3. **Proportionality**: All co-existence measures established should be proportionate, non discriminatory and science-based.

4. **Equity (fairness):** The issue of economic liability provisions that compensate non GM growers for adventitious presence of GM material is often raised in the co-existence debate. Historically, the market has adequately addressed economic liability issues relating to the adventitious presence of unwanted material in any agricultural crop[4] by placing the onus on growers of specialist crops (eg, seed, organic) to take action to protect the purity of their crops (such growers usually being rewarded by higher prices for taking such actions). If legislation was to be introduced that created new economic liability provisions for any negative economic consequences of adventitious presence of unwanted GMO material, it is reasonable to argue that the same principle should apply to all farmers regardless of their chosen production methods. On equity/fairness grounds, GM growers should have equal access to compensation for any negative economic consequences arising from the practices of neighbouring conventional or organic farmers (eg, loss of quality premia for adventitious presence of non GM material in GM crops or losses from the spread of pests and weeds from neighbouring farms with poor levels of pest and weed

[1] For example, grains of dent maize found in waxy maize

[2] For example, the threshold for impurities in most cereals is typically 2% (see section 5.1)

[3] In other words has been given approval for use and consumption on health, safety and environmental grounds

[4] The concept of economic liability should not be confused with environmental liability, which is a separate issue and which is addressed through the regulatory approval process

control). No one sector should be able to veto another – access and choice work both ways

5. **Practicality**: all co-existence measures should be based on legal, practical and scientific realities.

Developing good co-existence in your locality

The tools exist to facilitate good co-existence. These practices have been successfully enabling co-existence of GM and non GM crops (including organic) in North America (and Spain) for many years without government involvement. If you apply the five key principles and adapt these to local circumstances on a crop by crop basis, effective co-existence practices can be developed.

1. Introduction

One of the main subjects of current debate about the use of genetically modified (GM) crops relates to the economic and market implications of GM and non GM crops being grown in close proximity (ie, co-existing). Within this co-existence debate, anti GM groups often claim that GM and conventional (including organic) crops cannot co-exist without causing significant economic harm/losses to conventional and organic growers.

This paper[5] examines these issues, based on real world experience and puts forward five key principles for delivering workable co-existence management practices. These can be applied in any country, region or locality. These are based on, and drawn from four papers written by Brookes G & Barfoot P (2003 & 2004) on: co-existence of arable crops in North America, the non GM and organic market context in Europe, arable crops in the UK and maize in Spain[6].

2. What is co-existence?

Co-existence as an issue relates to '*the economic consequences of adventitious presence of material from one crop in another and the principle that farmers should be able to cultivate freely the agricultural crops they choose, be it GM crops, conventional or organic crops*'[7]. The issue is, therefore, not about product/crop safety[8], but relates solely to the production and marketing of crops approved for use.

3. When is co-existence an issue?

Adventitious presence of GM crop material in non-GM crops becomes an issue where consumers demand products that do not contain, or are not derived from GM crops. The initial driving force for differentiating[9] currently available crops into GM and non-GM has came from consumers and interest groups who expressed a desire to avoid support for, or consumption of, GM crops and their derivatives. This has subsequently been recognised by some in the food and feed supply chains (notably some supermarket chains, many with interests in organic farming and suppliers of GM event testing services) as an opportunity to differentiate their products and services from competitors and hence derive market advantage from the supply of non-GM derived products. This has been taken furthest in the organic sector, which has opted to prohibit the use of GMOs in (organic) production[10].

It is important to recognise that co-existence is only an issue when there is a distinct demand for non GM products/crops. If there is no distinct non GM demand, there is no (GM) co-existence issue. This has been the case in relation to most GM maize grown in Spain, where farmers adjacent to each other who grow maize, some GM and some non GM, both sell their output to animal feed compounders who do not differentiate raw materials according to their production method, and hence mix both GM and non GM supplies. As a result, there has

[5] The authors acknowledge that a funding contribution towards the researching of this paper was provided by Agricultural Biotechnology in Europe (ABE). The material presented in this paper is, however the independent views of the authors – it is a standard condition for all work undertaken by PG Economics that all reports are independently and objectively compiled without influence from funding sponsors

[6] All four papers are available on www.pgeconomics.co.uk

[7] Source: European Commission 2003

[8] Commercially grown GM crops having obtained full regulatory approval for variety purity, use in livestock feed, human health and safety and the environment. The issue of environmental liability (sometimes confused with economic liability) is addressed through the regulatory approval process

[9] Generally referred to as either segregation or identity preservation

[10] This prohibition having been enshrined in legislation (eg, the European Organic Production Regulation 2092/91 (as amended) or the United States Department of Agriculture Organic Standards)

been no requirement (or need) to segregate the two crops or to minimise the chances of adventitious presence of GM material being found in the non GM crop.

Whilst market factors largely determine whether there is a distinct demand for non GM products (and this resulting in a co-existence issue), legal requirements may also contribute. Legal requirements essentially fall into two distinct categories:

- Where there are labelling requirements for products containing or derived from GMOs. These include, for example the European Union (EU) where the threshold for positive labelling of food and feed products containing or derived from GM crops is 0.9%, and Japan where positive labelling of GM content in food products is required if the GM content is 5% or more;
- Where one country has permitted the legal planting and use of a crop containing a GM trait but another country has not permitted the importation and use of crops/derived products containing this GM trait. For example, GM papaya is permitted for planting and consumption in the USA but is not currently permitted for importation and use in Japan. Also, some GM maize traits (eg, resistance to the corn rootworm pest) are permitted for planting and use in the USA but are not currently permitted for importation and use in the EU.

4 The non GM market context

The demand for non GM products is probably greatest (in a global context) in the EU. Here the non GM market is concentrated in the markets that use soybeans/derivatives and maize. The level of demand for certified non GM soy/derivatives and maize[11] is within the range of 16% to 27% of total soy/derivative use and 25%-36% of total maize usage (Table 1). In North America, the level of demand for certified non GM soy and maize is much lower and is probably equal to less than 5% of total demand[12].

Table 1: Estimated GM versus non GM soy and maize use 2002-03 in the EU (million tonnes)

Product	Market size	Non GM share	Non GM share (%)
Soy			
Whole beans	1.5	0.33	22
Oil	2.12	0.83	39
Meal	30.77	3.69-8.3	12-27
Total			**16-27**
Maize			
Food & starch	8.97	6.28	70
Feed	29.25	2.92-7.31	10-25
Seed	0.78	0.55	70
Total	**39**	**9.75-14.14**	**25-36**

Source: PG Economics, American Soybean Association, Oil World

Note: The range for the estimated share of non GM demand in the animal feed sector reflects the broad range of views and limited research in the sector

[11] This refers to the level of demand that actively requires supplies to be certified as non GM to at least the thresholds laid down in the EU labelling regulation

[12] The author has not identified any literature that has attempted to quantify the size of this market in North America. The less than 5% estimate is the author's qualitative view

5 Co-existence is nothing new

5.1 How does adventitious presence arise ?

Adventitious presence of unwanted material can arise for a variety of reasons. These include, seed impurities, cross pollination, volunteers (self sown plants derived from seed from a previous crop), and may be linked to seed planting equipment and practices, harvesting and storage practices on-farm, transport, storage and processing post farm gate. Recognising this, almost all traded agricultural commodities accept some degree of adventitious presence of unwanted material and hence have thresholds set for the presence of unwanted material. For example, in most cereals, the maximum threshold for the presence of unwanted material (eg, plant material, weeds, animal filth, dirt, insect parts, stones, seeds of other crop species) commonly used is 2% (by weight).

5.2 Dealing with adventitious presence is nothing new on the farm

Farm level practices (eg, separation of crops by space and time, communicating with neighbours, use of good husbandry, planting, harvest and storage practices) to minimise levels of adventitious presence (and hence delivering good/successful co-existence) have been in operation, by farmers, for many years.

5.2.1 Examples of long standing co-existence

a) Certified seed production

Seed production systems operate to threshold levels for the presence of non pure seed (off types). They are based on specified separation distances between the seed production plot and other plots of the same species and time intervals between a seed crop and any other crop of the same species grown on the plot. These are backed up by seed inspection and testing agencies. Failure to meet the purity standards results in seed not being certified and the relevant seed premium being lost to the grower (ie, the crop has to be sold as a non seed crop).

In relation to seed production for the main arable crops for which GM traits have already been commercialised (or are most likely to be commercialised in the EU in the next few years), the key factors considered to affect purity levels are:

- *oilseed rape:* Cross pollination and volunteers are the main factors affecting purity. To ensure purity standards are regularly met, the minimum separation distance for seed crops is 100 metres, although for hybrid oilseed rape this is increased to 300 metres. To minimise the chances of volunteers compromising seed purity, no oilseed rape crop should precede a seed crop (of oilseed rape) for five years;
- *sugar beet*: As the crop is normally biennial (produces seed only in the second year) but is harvested at the end of the first growing season, plants rarely flower. The only scope of cross pollination occurring comes from bolters (weed beet). Control of weed beet is therefore an important and accepted part of good husbandry practice in sugar beet cultivation;
- *maize*. Cross pollination from adjacent (non seed) maize crops is the main factor affecting purity. As such, a separation distance of 200 metres is typically applied to ensure maintenance of purity standards[13]. Growers also use buffer rows around the

[13] In seed production, as much as 80% of the plants in a field (the detasseled female plants) do not produce pollen. As a consequence, they are highly receptive to both, pollen from the male plant, and to adventitious pollen carried in from

seed production plot, with one row considered to be approximately equal to 10 metres of non crop separation.

The conditions applied to certified seed production systems are based on practical field experience and take due account of year to year variations in prevailing weather conditions and the activities of bees and other pollinating insects. These species-specific practices generally deliver seed to the purity standards required.

A few instances have arisen in recent years where adventitious presence of GM material has been found in some non GM seed. For example, in 2000 some maize seed lots imported into France from North America were found to have low levels of GMO presence (under 0.2%) and some spring oilseed rape varieties imported from Canada into the UK had GMO presence levels of under 1%. As a result of these instances there has been re-evaluation of conditions and procedures by seed producers to reduce further the likelihood of adventitious presence occurring. For example, in relation to maize seed production in the USA the separation distances for foundation standard seed has increased from 200 metres to 270 metres. In addition, increased testing of seed prior to planting first generation (seed) crops has also been initiated.

b) High erucic acid oilseed rape (HEAR)

HEAR varieties have desirable properties for the manufacture of industrial oils. However, the high erucic acid component of the seed oil is an anti nutritional product and should not be consumed on health and safety grounds. It is therefore most important that the cultivation of HEAR crops do not contaminate other oilseed rape (often referred to as double zero varieties) grown for uses in human food and animal feed. Contracts for growing HEAR crops usually require that only certified seed of HEAR varieties is used, seed drills are required to be cleaned prior to use, a separation distance of 50-100 metres[14] is maintained from other oilseed rape crops sown in the same season[15], all cultivation and harvesting equipment should be cleaned before use and post harvest segregation is maintained to minimise admixtures. Strict application of these procedures is promoted by contract testing and the use of penalties (including rejection of crops) if the set parameters for the oilseed fatty acid content are not met. The threshold for admixture of HEAR in other (double zero) oilseed rape is 2%[16] although recorded levels of ad-mixture are usually found to be much lower (see below).

Adherence to the contractual requirements and in particular the separation distances, comes (where applicable) by voluntary arrangements between adjacent farmers, although in many instances there is no need to involve other farmers, as separation distances can be adequately dealt with on-farm (eg, 50 metres is less than the width of an average field). Farmers growing HEAR usually discuss cropping plans with their neighbours, identify and set rotation patterns by mutual agreement.

Evidence from Germany suggests that the applied 100 metre separation distance delivers more than 95% of double zero seed lots with an erucic acid level of below 0.2% and only a

neighbouring fields by the wind. Also because of inbred depression, the male parent plant usually produces less pollen than other maize, and this pollen is usually produced with a lack of synchrony towards the female maturity. In order to ensure a high degree of purity of the hybrid seed (usually 99.5%), strict growing conditions are respected. These include, for example large separation distances from neighbouring fields (eg, 200 metres). In contrast, maize grain grown for direct use (food, feed, industrial) contains 100% fertile parent plants. The amount of pollen present and its competitivity are much higher than in seed production fields, so the influence of adventitious pollen from neighbouring fields is smaller. Therefore maintaining a degree of purity in a grain maize field (where this is a desired outcome, for example, a non GM crop located near a GM crop) requires the application of less strict measures (eg, separation distances) than in the case of seed production

[14] 50 metres UK, 100 metres Germany

[15] It is not necessary to have separation distances between crops sown in different seasons, eg winter sown double zero and spring sown HEAR

[16] To breach the 2% threshold for erucic acid in the oil would require a 4% cross pollination of seed

few seed lots contain more than 0.5%. Research conducted in the UK by Kings[17] in 1993-95 which planted HEAR varieties in plots adjacent to double zero varieties (maximum distance between plots was 9 metres) found that the level of erucic acid found in double zero crops was less than 0.5%.

5.2.2 Examples of GM and non GM crop co-existence practices

a) North America

In relation to the implementation of co-existence practices (where relevant) for the planting of GM and non crops in North America, this has involved actions being taken by both GM and non GM growers.

All suppliers of GM seed to farmers in North America provide farmers with 'Technology Use Guides' or 'Crop Stewardship Guides'. These provide recommendations for use of the GM products (eg, herbicide use for weed control recommendations) and some advice on 'co-existence issues' that target maintaining the purity of non GM crops growing on GM crop planting farms, on nearby farms, in storage or when supplied to buyers. Issues covered include:

- Pollen movement: ways of minimising the chances of cross pollination through the siting of crops in relation to prevailing wind directions, use of buffer crops and barriers, timing of plantings, varieties planted (with different flowering times), separation distances and removal (ie, separate harvesting and segregation) of outer strips of crop in a field (eg, some speciality corn crops require the removal of the outer 9 metres (30 feet) of a crop to ensure the removal of impurities from adjacent (non speciality) corn crops);
- Holding discussions with neighbours about planting intentions;
- Holding discussions with grain buyers to ensure that contractual requirements are identified (eg, whether GM traits not yet approved for importation into the EU are accepted).

All farmers of herbicide tolerant crops are also provided with advice on managing volunteers in subsequent crops[18]. This advice covers aspects of an integrated weed management system, the majority of which is equally applicable to non GM varieties of these crops, and includes crop rotation, rotation of herbicides, rotation of herbicide tolerant traits, rotation of timing of herbicide applications, rotation of timing of tillage and use of certified seed.

Equally non GM growers, especially those in the organic sector are provided with advice on similar measures from some of their advisors and certifying bodies.

b) Maize in Spain

Spain is the main EU country where commercial planting of GM crops takes place (insect resistant maize since 1998). Here, as in North America, farmers planting GM maize are advised by seed suppliers about possibilities of adventitious presence of GMOs from their crops being found in neighbouring non GM crops and how best to minimise this occurring. This advice focuses on ensuring that farmers take into consideration prevailing wind directions, flowering dates of different varieties and the planting of border rows in bands between the GM crops and neighbouring non GM crops that might be destined for sale into a

[17] The leading supplier of HEAR seed in the UK

[18] See for example CropLife Canada, Controlling herbicide tolerant volunteers in a succeeding crop: a best practice guide. www.croplife.ca

usage sector that specifically requires the maize to be certified as non GM or organic. At least four rows of conventional maize planted between GM crops and 'vulnerable' non GM crops are recommended.

c) *UK: GM farm scale trials (FSEs)*
In the UK, no commercial plantings of GM crops have occurred to date. However, extensive FSEs (260) have been conducted for some GM herbicide tolerant arable crops. All of the FSEs were required to comply with the Supply Chain Initiative on Modified Agricultural Crops (SCIMAC) guidelines. These guidelines specified practices for storage and planting of seed, crop management, harvesting, storage of harvested crops, neighbour notification, monitoring and record keeping and separation distances to be adopted when growing GM (herbicide tolerant) crops.

The SCIMAC separation distances (Table 2) were based on a combination of current seed production legislation, established practice for producing specialist crops like HEAR and seed crops, knowledge of pollen distribution and cross-pollination and 'best' available current scientific knowledge. They were set using a precautionary approach and with the intention that review would take place in the light of experience. The application of this precautionary approach resulted in the separation distances for non seed crops (including organic) being significantly greater than the distances required to comply with the EU labelling threshold of 0.9%. For example, a 25 metre separation distance (or the application of four rows of buffer crop) is widely considered to be sufficient to meet the 0.9% labelling threshold for maize[19] yet greater separation distances were applied in SCIMAC.

Table 2: SCIMAC separation distance for same species

Crop type	Non-GM crops	Certified seed crops	Registered organic crops
Oilseed rape	50 metres (100 metres for varietal associations and partially restored hybrids)	200 metres	200 metres
Sugar beet	6 metres	600 metres	600 metres
Forage maize	200 metres sweet corn 80 metres forage maize	200 metres	200 metres

Notes:
1. The non GM crops were effectively working to a legal threshold of 1%, whilst certified seed and organic crops were assumed to operate to tighter commercial thresholds
2. The 600 metre separation distance for sugar beet grown for seed is of no practical relevance to the UK because there is no sugar beet seed production in the UK

6 Have GM and non GM crops co-existed successfully?

The evidence to date shows that GM and non GM crops (including organic) have successfully co-existed without causing economic/marketing problems since GM crops were first grown commercially in 1995. Specifically in relation to organic crops, which are most frequently cited as the type of production perceived to be most likely to experience co-existence difficulties with GM crops, the evidence is also clear – successful co-existence has been possible.

[19] See for example, Henry C et al (2003) Farm scale evaluations of GM crops: monitoring gene flow from GM crops to non GM equivalents in the vicinity: part one forage maize, DEFRA report EPG/1/5/138 and Mele E et al (2004) First results of co-existence study: European Biotechnology Science & Industry News No 4, vol 3

6.1 The North American experience

North America is probably the most relevant market to examine whether GM and non GM crops have co-existed successfully, given the penetration of GM crops in total plantings of some key arable crops. Figure 1 shows the relative importance of different production systems for the three main food and feed crops for which GM technology is currently commercially available to farmers. This illustrates the importance of GM technology – accounting for 60% of total plantings of oilseed rape, maize and soybeans, with conventional production accounting for almost all of the balance, and organic production accounting for a minute 0.22% of total plantings[20].

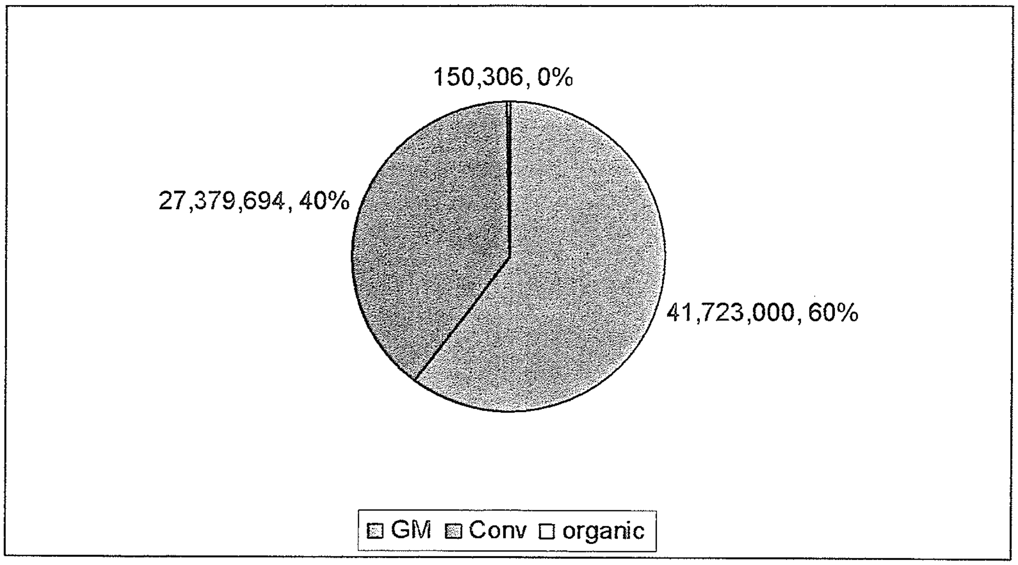

Figure 1: Share of GM, conventional and organic production systems in soybeans, maize and canola 2002 in North America (hectares)

Sources: USDA, ISAAA, University of Manitoba
Notes: Canadian organic area of soybeans and maize based on US organic shares: total share is 0.22%

The most relevant GM/organic co-existence points that emerge from analysis of the North American experience are:

- Survey evidence amongst US organic farmers (2003) shows that the vast majority (96%) have not experienced any loss of organic sales or downgrading of produce as a result of GM adventitious presence having been found in their crops. Where a small number (4%) report some losses/downgrading this has been due to a marketing decision taken by their certifying body or customer rather than any requirement under national (USDA) organic regulations[21];
- The US organic areas of soybeans and maize have increased by 270% and 187% respectively between 1995 and 2001[22], a period in which GM crops were introduced

[20] The respective organic shares per crop are 0.24% for soybeans, 0.12% for maize and 0.04% for oilseed rape

[21] The USDA National Organic Standards whilst prohibiting the use of GM varieties states that 'the presence of a detectable residue of a product of excluded methods alone does not necessarily constitute a violation of this regulation. As long as an organic operation has not used excluded methods and takes reasonable steps to avoid contact with the products of excluded methods as detailed in their approved organic system plan, the unintentional presence of the products of excluded methods should not affect the status of an organic product or operation'

[22] Whilst the % change in organic plantings has shown a substantial increase, the areas planted to organic soy and maize (in 2001) remained minute at 0.24% and 0.12% respectively of total soy and maize plantings

and reached 68% and 26% shares of total plantings of soybeans and maize respectively by 2001. Also, the states with the greatest concentration of organic soybean and maize crops are often states with above average penetration of GM crops (eg, Iowa and Minnesota);

- In the case of canola (spring oilseed rape), the organic area has historically been very low (under 0.1% of total canola plantings). This very low level of planting essentially reflects agronomic and husbandry difficulties in growing organic canola and the limited nature of the market – it is not related to any co-existence problems with GM canola.

6.2 Europe

The evidence to date shows that GM, conventional and organic maize crops in Spain have also co-existed successfully. In over 90% of cases where Bt maize has been grown in Spain, neighbouring fields have either been Bt maize or a conventional maize variety being sold for feed usage, where the buyer does not differentiate between GM and non GM sources of supply. Hence there have been few occasions where co-existence measures have needed to be implemented. Isolated instances[23] of GMO adventitious presence in organic maize crops have been reported but these may be attributable to poor implementation of good co-existence practices (ie, using non organic, conventional seed that had not been tested prior to use and/or poor on-farm or post-farm segregation).

Similarly, in the UK, the 260 FSEs have successfully co-existed with conventional and organic crops. No conventional or organic crops near to the FSEs found any adventitious presence levels of GMOs that resulted in economic losses and there was no loss of organic status on any neighbouring (organic) farm.

6.3 Overall perspective

Overall, the real world experience shows that GM crops have successfully co-existed with conventional and organic crops. This is not surprising given the long history that farmers have of successfully growing specialist crops (eg, seed production, waxy corn, high erucic acid oilseed rape) for many years, near to crops of the same species (including GM crops), without compromising the high purity levels required. North American and Spanish farmers have also been successfully growing and channelling some GM and non GM crops of the same species into different markets. A small number of instances of adventitious presence of GM events have been found in non GM and organic crops (and resulted in possible rejection of deliveries by buyers or imposition of contractual price penalties) but this has usually been caused by deficiencies in application of good co-existence practices rather than any failure of the practices themselves.

7 Key principles for co-existence of GM and non GM crops

Drawing on the evidence presented above[24], five key co-existence principles can be identified.

7.1 Context

It is important to determine the relative importance of different crop production systems (GM, conventional and organic) based on planted area, production and economic value, and to examine the size of the non GM (including organic) markets. These properties are important

[23] Two, both reported in 2001

[24] For additional detail see the four co-existence papers referred to in the bibliography

considerations when assessing the likelihood of adventitious presence of material from one production system affecting another and the potential economic impacts. Of key importance here are the following points:

- If there is no distinct non GM demand, there is no (GM) co-existence issue;
- If the level of demand for certified non GM products (including organic) is small, then the likelihood of GM and non GM crops (for which the non GM status is important to buyers) being found growing near to each other will be fairly limited. As indicated in section 6, the evidence to date shows that the non GM market in crops for which GM crops have been commercialised (or may be commercialised in the EU in the next 5-10 years) is relatively small. The organic area of these crops is also minute, both in North America and the EU (less than a quarter of one per cent).

Overall, context is particularly important to the principle of proportionality – see section 7.3.

7.2 Consistency

Producers and those overseeing the integrity/purity of crops/derivatives should be consistent in their behaviour towards the adventitious presence of all unwanted material, including GM derived material. It is unrealistic to expect 100% purity for any crop/product and this is why thresholds are set for adventitious presence of unwanted material.

These (thresholds) should be proportionate to the risks attached to the presence of the unwanted material:

- for the adventitious presence of (unwanted) material that pose known health and safety risks (eg, mycotoxin levels in cereals), it is appropriate to operate to very low threshold levels (eg, to the limits of reliable detection);
- for adventitious presence of (unwanted) material that affect product integrity, purity, quality and functionality (eg, impurities, weed/plant material, seeds/grains of off types[25]), wider thresholds are appropriate. Whilst these (thresholds) vary by crop and use, they are typically set at levels between 1% and 5%[26]. Practicality and cost considerations are important factors affecting the setting of this category of thresholds because in general, the tighter the threshold, the higher the cost and greater the difficulty in meeting such thresholds.

In respect of the adventitious presence of GM material (which has been given regulatory approval for use[27]) in non GM crops, the threshold set, by the EU's GM labelling legislation, at 0.9% falls appropriately into the second category referred to above.

Against this background, there are notable <u>inconsistencies</u> practiced by some certification bodies in the organic sector. These inconsistencies fall into the following two main categories.

7.2.1 Testing of organic produce for the presence of GMOs

Organic certification is based on certifying the production method rather than giving an end product guarantee as to the product's freedom from GMOs or excluded products. Adventitious presence of such material can occur from circumstances beyond the reasonable control of the organic producer and therefore, the identification of such material (via end product testing) is not

[25] For example, grains of dent maize found in waxy maize
[26] For example, the threshold for impurities in most cereals is typically 2% (see section 5.1)
[27] In other words has been given approval for use and consumption on health, safety and environmental grounds

used to de-certify organic status on produce provided growers can demonstrate their adherence to the organic farming practices and rules. Whilst this pragmatic principle should apply to possible adventitious presence of GMOs[28], some organic certification bodies advocate the practice of undertaking testing for GMO presence, with all crops found to have detectible GMO presence de-certified (ie, the organic status is lost). This practice is inconsistent with the treatment of other unwanted material and with the treatment of crop protection products for which thresholds for their safe use exist[29]. This (practice) may, therefore, be unfairly penalising organic farmers whose crops are found to contain very low levels of GMOs through no fault of their own. Furthermore it is possible that 'positive' GMO presence in an organic crop might result from naturally occurring DNA (as found in the soil), from GM plant material that has not introgressed with the organic crop (ie, pollen on the surface of a crop) or be due to testing error.

7.2.2 Adoption of a de facto threshold for the presence of GMOs of 0.1%

Against a background of no organic sector-specific legal, *de minimis* threshold existing for the presence of GMOs in organic produce in both North America or the EU (ie, the 0.9% EU labelling threshold applicable to GMO presence in any product applies equally to organic produce), this is inconsistent with other thresholds and derogations operated in the organic sector. For example, the EU organic standards allow thresholds[30] of up to 5% for the presence of non organic ingredients in some processed foods, buyers of organic produce invariably operate to the same thresholds as apply to conventionally produced crops in respect of the presence of foreign material (eg, 2% for materials like dirt, weeds, stones in maize) and there are derogations for the use of:

- some pesticides such as copper-based fungicides on potatoes and Bt (bacillus thuringiensis), a bacterial fungicide used for the control of caterpillars - the Bt sprays are obtained by mass producing (using fermentation methods) the bacteria, which is then sprayed onto crops, killing caterpillars when they eat the (Bt) bacteria which contain a natural toxin to caterpillars. This naturally occurring toxin is the same element expressed in GM (Bt) maize, which is not permitted in organic agriculture;
- non organic seed;
- crop species and seed varieties derived from 'unnatural' plant breeding techniques (eg, triticale, a crop derived from the use of embryo rescue and chromosome doubling techniques);
- straw from conventional cereals can be used for livestock bedding – this is subsequently spread on organic production land as an important source of crop nutrients;
- up to 20% of ingredients used in organic animal feed can be derived from non organic ingredients[31], and
- some ingredients derived from GMOs may be allowed by certification bodies because of the lack of availability of non GM derived alternatives; this relates to possible use of some GM derived processing aids in some food products and veterinary medicines.

In all these cases, the organic status of the crop is <u>not</u> de-classified and consumers pay the full organic premium for these products.

[28] See for example IFOAM position paper on genetic engineering and GMOs; www.ifoam.org, page 2 and the USDA Organic Standards

[29] It is also interesting to note that all pesticides approved for use have safety-based maximum threshold levels for presence in crops. Conversely, GM crops approved for commercial use do not require the application of such thresholds for safe use

[30] There is also no requirement to label for the presence of these 'allowed' non organic ingredients/products, provided the thresholds are met

[31] Against the background of the 20% legal maximum for the use of non organic ingredients, some certification agencies apply a lower threshold of, for example 10%

Some in the organic sector seek to justify the practice of testing for GMO presence in organic produce to a 0.1% threshold as being necessary to maintain organic product integrity and consumer confidence. However, the inconsistency of this practice and the operation of wider tolerances and derogations for the use of non organic inputs/ingredients, undermines this consumer confidence argument. The more consumers are made aware of these 'allowances' for the use of non organic ingredients and inputs, the greater the potential for loss of confidence in the integrity of all organic products.

7.3 Proportionality

All co-existence measures established should be proportionate[32], non discriminatory and science-based. If highly onerous GM crop stewardship conditions are applied to all farms[33] that might wish to grow GM crops, even though the vast majority of such crops would not be located near to organic-equivalent crops or conventional crops for which the non GM status is important (see context), this would be disproportionate (and inequitable: see below). In effect, conventional farmers, who account for the vast majority of the current, relevant arable crop farming area could be discouraged from adopting a new technology, that it has been shown to deliver farm level benefits (yield gains, cost savings) and wider environmental gains (reduced pesticide use; switches to more environmentally benign herbicides, reduced levels of greenhouse gas emissions[34]).

7.4 Equity (fairness)

The issue of economic/marketing liability provisions that compensate non GM growers for adventitious presence of GM material is often raised in the co-existence debate. Historically, the market has adequately addressed economic liability issues relating to the adventitious presence of unwanted material in any agricultural crop by placing the onus on growers of specialist crops (eg, seed, organic) to take action to protect the purity of their crops (such growers usually being rewarded by higher prices for taking such actions). If legislation was to be introduced that created new economic liability provisions for any negative economic consequences of adventitious presence of unwanted material, it is reasonable to apply the same principle to all farmers regardless of their chosen production methods.

More specifically, it can be argued that GM growers should have equal access to compensation for adventitious presence of material from conventional or organic crops as conventional and organic producers have from GM growers. For example, on equity grounds a case could be made for providing economic compensation/liability in the following circumstances:

- *For farmers using GM technology for adventitious presence of non GM material*: the hypothetical (future) scenario of a farmer growing a crop with a GM quality trait that loses its (quality trait) price premia because of adventitious presence of non GM material above an agreed threshold; or equally the current scenario of a grower of a

[32] See EU Commission 'Recommendations on guidelines for the development of national strategies and best practices to ensure co-existence of GM crops with conventional and organic farming', 23 July 2003

[33] For example the setting of substantial separation distances between GM crops and any conventionally grown equivalent that go beyond what is reasonably required to meet legal requirements such as the EU's labelling threshold of 0.9%

[34] These impacts of the technology have been quantified and reviewed in a number of publications, including PG Economics (2003) Consultancy support for the analysis of the impact of GM crops on UK farm profitability, report for the Strategy Unit of the Cabinet Office, Ford Runge C & Ryan B (2003) The economic status and performance of plant biotechnology in 2003: adoption, research and development in the USA, CBI Washington and Gianessi et al (2002) Plant biotechnology current and potential impact for improved pest management in US agriculture: an analysis of 40 case studies, NCFAP, USA

specialist crop (eg, conventional or GM seed) that finds adventitious presence of unwanted varieties in their crops;

- *For all conventional farmers for adventitious affliction of neighbours pests, diseases and weeds*: for example an organic potato farmer who suffers a blight attack (mainly because of the much higher risks of infection in an organic system compared to a conventional production system) and this spreads to adjacent conventional farms, causing yield losses and/or the need to apply additional sprays to curb the disease;
- *For conventional farmers for loss of the benefits of new technology*: some farmers will be interested in adopting cost saving, higher yielding and more environmentally benign GM technology but may be discouraged from doing so by costly and dis-proportionate co-existence and liability conditions.

7.5 Practicality

All co-existence measures should be based on legal, practical and scientific realities. In particular, whilst absolute purity of the segregated product is striven for, it is a fact of any practical agricultural production system that accidental impurities can rarely be totally avoided (ie, it is virtually impossible to ensure absolute purity). To expect a 100% level of purity as the expected goal is therefore unrealistic and the stance taken by some organic certification bodies and NGOs that organic produce should have a zero tolerance threshold for adventitious presence of GM material is impractical (and dis-proportionate and inconsistent: see above).

8 Co-existence requires co-operation

Successful co-existence of different agricultural production systems requires mutual respect and shared responsibilities by all parties. Responsibility for implementation of co-existence measures should involve both GM and non GM growers communicating amongst themselves and implementing appropriate management practices.

The experience of North America shows that shared responsibilities for implementing co-existence has worked (without government involvement). The traditions of farmers growing specialist crops taking responsibility for adopting measures to protect the integrity and purity of their crops (in the knowledge that they are rewarded through price premia for incurring any associated costs involved) have been blended with farmers adopting new technology (GM) adhering to responsible crop stewardship conditions.

9 Developing co-existence guidelines or rules in any region, country or locality

The key messages to be taken from this paper are that the tools exist to facilitate good co-existence. These practices have been successfully enabling co-existence of GM and non GM crops (including organic) in North America since 1995. If the five key principles presented above (section 7) are used and adapted to local circumstances on a crop by crop basis, effective co-existence practices can be developed.

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Farm & Ranch Guide

Ag News: Livestock News

NU research: Feeding, grazing GM corn doesn't affect livestock performance

LINCOLN, Neb. - The latest University of Nebraska research confirms that feeding or grazing genetically modified corn has no effect on livestock performance.

These studies involved Bt corn for rootworms and Roundup¨ Ready corn. Results reinforce earlier findings on the feed value of genetically modified crops by scientists at Nebraska and at other land-grant universities, said Animal Scientist Galen Erickson.

The bottom line for livestock producers is they can expect the same livestock performance whether they feed currently available genetically modified corn or conventional corn, he said.

NU Institute of Agriculture and Natural Resources animal scientists have evaluated performance of livestock fed or grazed on genetically modified corn for the last three years to provide information on these new types of corn, he said. Sixty percent of the U.S. corn supply is fed to livestock.

"It's important that if we change corn traits that we do not decrease the feeding value," Erickson said. "Bt and Roundup Ready corn are very advantageous from an agronomic point, but we needed to research this to ensure that the feed value was not negatively impacted."

Feeding trials for beef, dairy and swine were conducted at NU's Agricultural Research and Development Center near Mead, Neb.

One experiment found no difference in steer performance among steers that grazed corn stalks from either Bt corn for rootworms, Roundup Ready corn or conventional corn during a 60-day grazing period.

In a 2001 study, steers showed no preference for Bt or conventional corn. During the grazing period, 47.5 percent of the steers were observed grazing Bt residue, while 52.5 percent were observed grazing conventional cornstalks.

Producers sometimes report that cattle spend more time grazing conventional than Bt cornstalks. However, Erickson said this apparent preference probably is because there's more corn left after harvest in conventional corn fields with insect damage.

In two finishing trials, 200 steers were fed rations containing either Roundup Ready corn or a conventional but genetically similar hybrid, and 200 crossbred yearling steers received Bt corn for rootworms or genetically similar conventional corn. Animal performance and carcass data for these trials showed no significant differences.

"Overall, performance was not negatively affected in the corn residue grazing or feedlot experiments, suggesting that the corn rootworm-protected hybrids and Roundup Ready corn hybrids are similar to conventional corn grain and residues when utilized by beef cattle," Erickson said.

In an experiment with swine, NU Swine Nutritionist Phil Miller compared pig growth and percent lean in pigs fed Bt corn for rootworms or conventional corn. In another study, they compared nutritional value and nitrogen digestibility for young pigs fed Roundup Ready corn and those fed conventional corn.

Neither study revealed significant differences, Miller said.

Researchers evaluated 72 barrows and 72 gilts for the Bt study and 12 barrows for the Roundup Ready study.

Results showed Bt corn does not affect pig performance and that Roundup Ready corn can be fed to young pigs without affecting nitrogen or energy digestibility, Miller said.

Two dairy studies also were conducted to evaluate the effect of Roundup Ready corn and Bt corn for rootworms on feed intake and milk production. Findings showed similar performance for genetically modified and conventional corn as measured by efficiency of milk production for lactating dairy cows.

FOX NEWS .com

Anti-Biotech Film a 'Crockumentary'

Thursday, October 06, 2005

By Steven Milloy

The biotech scare is back – or, at least, a new movie is trying to bring it back. Playing in small movie houses, "The Future of Food" dusts off, and presents in ominous fashion, all the Greens' long-discredited arguments against agricultural biotechnology.

Produced by Deborah Koons Garcia, the widow of the Grateful Dead's Jerry Garcia, the movie's overriding themes are allegations that biotech crops and food are unsafe and that a government-industry cabal is foisting dangerous products on an unwitting public.

Nothing could be farther from the truth.

Biotech crops and foods are among the most thoroughly tested products available. No other food crops in history have been so thoroughly tested and regulated. Before biotech products are marketed, they undergo years of safety testing including thousands of tests for potential toxicity, allergenicity and effects on non-target insects and the environment.

"The Future of Food," for example, dredges up the 2000 scare involving a biotech corn that had not yet been approved for human consumption but that was detected in Taco Bell taco shells. A few consumers, egged on by anti-biotech activists, alleged the corn caused allergic reactions. But the movie glossed over the fact that the U.S. Centers for Disease Control and Prevention tested those consumers and reported there was no evidence that the biotech corn caused any allergic reaction in anyone.

Another long-buried myth excavated by Garcia was that biotechnology harms biodiversity. But so far it doesn't appear to represent any greater risk to biodiversity than conventional agriculture and it actually seems to have some demonstrable beneficial impacts on biodiversity.

An infamous biodiversity scare featured in the movie involved Monarch butterflies. The scare occurred during 1999-2000 when the media trumpeted alarmist results from two laboratory studies reporting that biotech corn might harm Monarch butterfly larvae. Subsequent field studies soon debunked the scare, reporting that Monarch larvae actually fared better inside biotech cornfields than in natural areas because of less pressure from predators. Needless to say, Monarchs in biotech cornfields also did much better than those in conventional cornfields sprayed with insecticides.

The movie claims that once biotech crops are planted, control over them is lost and they "contaminate" non-biotech or organic crops. This is misleading since 100 percent purity has never been the reality in agriculture. Biological systems are dynamic environments, meaning that regardless of the method of production -- conventional, organic or biotech -- trace levels of other materials are always present in seed and grain. Since all commercial biotech traits are fully approved by U.S. regulatory agencies, their presence -- in large amounts or trace amounts -- is fully legal and safe.

With respect to organic farmers, the Department of Agriculture's rules for organic products specifically say that the certification of organic products is *process-based* -- meaning that if the proper *processes* are followed, the unintended presence of non-organic or biotech traits doesn't disqualify the product from being labeled as "organic."

To date, biotech crops haven't harmed organic farmers. The coexistence of biotech, conventional and organic corn, soybean, and canola has been effectively working since 1995, when the first biotech crops were introduced. During that period, in fact, both biotech and organic farming have grown remarkably.

Garcia wants movie viewers to overlook the fact that U.S. regulators -- including the Department of Agriculture, Environmental Protection Agency and the Food and Drug Administration -- have established a robust framework and rigorous process for evaluating biotech product safety. Developers spend years generating data for one product to be submitted for approval.

A major take-home message of the movie is that consumers should demand labeling of biotech foods. But this would only increase the cost of food production while failing to provide any meaningful information to consumers. Biotech crops have been determined by regulators to be essentially equivalent to those of conventional crops. Corn is corn, in other words, no matter what anti-biotech activists would have us believe.

While emphasizing "scare," the movie overlooks biotechnology's advantages. Biotech crops require less tilling. This reduces soil erosion; improves moisture retention; increases populations of soil microorganisms, earthworms and beneficial insects; and reduces sediment runoff into streams.

The movie mocks biotechnology's potential value to the developing world, characterizing the argument as one designed for public relations use. But biotech crops such as "golden rice" could help with the severe Vitamin A deficiency that afflicts hundreds of millions in Africa and Asia, including 500,000 children who lose their eyesight each year.

As pointed out by Greenpeace co-founder Patrick Moore, now a vociferous critic of the activist group, "Greenpeace activists threaten to rip the biotech rice out of the fields if farmers dare to plant it. They have done everything they can to discredit the scientists and the technology.

"A commercial variety is now available for planting, but it will be at least five years before Golden Rice will be able to work its way through the Byzantine regulatory system that has been set up as a result of the activists' campaign of misinformation and speculation," Moore said. "So the risk of not allowing farmers in Africa and Asia to grow Golden Rice is that another 2.5 million children will probably go blind."

Garcia's "The Future of Food" is steeped in the Greens' tragic campaign of misinformation. Many long-time anti-biotech campaigners helped her make the movie, in which not a balancing thought or counter-opinion is presented.

The "Future of Food" purports to be a "documentary" -- a movie that sticks to the facts. It doesn't. Hollywood will need a new Oscar category for this one. How about "crockumentary"?

Steven Milloy publishes JunkScience.com and CSRwatch.com, is adjunct scholar at the Cato Institute, and is the author of Junk Science Judo: Self-defense Against Health Scares and Scams (Cato Institute, 2001).

THE WALL STREET JOURNAL. OPINION FRIDAY, OCTOBER 14, 2005

Food for Thought

By Norman Borlaug
And Jimmy Carter

The past 50 years have been the most productive period in global agricultural history, leading to the greatest reduction in hunger the world has ever seen. The Green Revolution, as this period came to be known in the developing world, has kept more than one billion people from hunger, starvation, and even death.

Many factors contributed to the Green Revolution. The doubling of the global area under irrigation was certainly important. But at the core was the development and application of new high-yielding, disease- and insect-resistant seeds, new products to restore soil fertility and control pests, and a succession of agricultural machines to ease drudgery and speed everything from planting to harvesting.

It took around 10,000 years for the world's farmers to reach their current production of nearly six billion gross tons of food, consumed virtually in its entirety by 6.4 billion people annually. Within 50 years, we will have to increase this amount by at least another 50%—to nine billion tons. Most likely we will have to achieve this feat on a shrinking agricultural land base, and with most of the production increases occurring in those countries where it is to be consumed.

However, agricultural science is increasingly under attack by groups and individuals who, for *political* rather than scientific reasons, are campaigning to limit advances, especially in new fields such as genetic modification (GM) through biotechnology. Despite this opposition, it is likely that 250 million acres will be planted to GM crops in 2005. Most of this acreage is in the industrialized world, although the area in middle-income developing countries is expanding rapidly. However, the debate over biotechnology in the industrialized countries continues to impede its acceptance in most poor, food-insecure countries.

More than half of the world's 800 million hungry people are small-scale farmers who cultivate marginal lands. New science and biotechnology have the power to address the agro-climatic extremes. Their use lies at the core of extending the Green Revolution to these difficult farming areas. Because there are so many hungry and suffering people, particularly in Africa, attacks on science and biotechnology are especially pernicious. Africa is facing a pandemic scourge of HIV/AIDS, malaria, and other diseases, a 30-year period of continuous degradation in soil fertility, frequent droughts and a burgeoning population.

This set of converging circumstances can lead to a human catastrophe in Africa on a scale the world has never seen. We know it is coming. We have the knowledge to avert it. If we put it off, solving it later will mean the acute suffering—and even death—of millions of innocents who could have been spared such a tragedy.

Messrs. Borlaug and Carter, Nobel Peace laureates for 1970 and 2002, respectively, are members of the Council of Advisors for the World Food Prize, which was awarded yesterday in Des Moines, Iowa.