Transgenic Crops

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Transgenic Crops describes the basics of genetic modification for agricultural purposes and a brief history of the technology and the governing policies surrounding it. This publication offers a brief overview of the main agricultural crops that have been genetically modified, the characteristics they express, and the market roles they play. Unintended consequences, economic considerations, and safety concerns surrounding the cultivation and dissemination of transgenic crops are also discussed. Biopharmaceutical aspects of transgenic crops are also briefly addressed. Economic, legal, and management concerns associated with these types of crops are addressed, as well as political and regulatory aspects. Implications of transgenic technologies for sustainable agriculture are briefly addressed along with concluding remarks. References and resources follow the narrative.

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To increase the genetic diversity of U.S. corn, the Germplasm Enhancement for Maize (GEM) project seeks to combine exotic germplasm, such as this unusually colored and shaped maize from Latin America, with domestic corn lines. Photo by Keith Weller, USDA ARS.

Introduction

The ability to transfer genetic material between two unlike species for agricultural purposes and crop production is the subject of this publication. Development of the science and methods to produce transgenic crops began around 1983 as part of a broader technological movement to modify organisms for economic, medical, military, and other general human ends.

Implications surrounding the modification of life carry significant and complex ethical issues. The capacity to produce transgenic crops causes great controversy among government agencies, business consortia, researchers, and certain nonprofit organizations. Particularly vocal are groups that represent the interests of civil society.

The quantifiable facts surrounding genetically modified foods seem less in dispute than the growing number of implications. These often take form in ethical arguments, which some supporters of transgenic crops write off as a defense of cultural artifacts. Yet the new capacities brought about by transgenic foods in particular reveal a general lack of research into these many implications.

For instance, in 2001, the Experiment Station Committee on Organization and Policy (ESCOP) and the Extension Committee on

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Organization and Policy (ECOP) published a report on critical issues in agricultural biotechnology and recommended responses. While calling for education of the public in regard to transgenic technologies, the report also called for land-grant research on transgenic crops to address four substantive concerns raised by the environmental community. (See Appendix 2.) To date, little of this type of research has been conducted, since it has never been adequately funded.

As of June 30, 2005, the U.S. Department of Agriculture and the National Agriculture Statistics Service (USDA/NASS) reported that transgenic varieties comprised 87 percent of all soybean acreage planted in the United States (up from 60 percent in 2001, and 85 percent in 2004). As of the same date, transgenic corn acreage planted was 52 percent (up from 47 percent in 2004). Transgenic upland cotton was 79 percent (up from 76 percent in 2004). No acreage was reported for transgenic varieties of other U.S. crops. (USDA/NASS, 2005) (See Table 1.)

Three types of transgenic produce have been commercialized—sweet corn, winter squash, and papaya. As of January 6, 2006, the following fruit and vegetable crops have been granted deregulated status by the USDA Animal and Plant Health Inspection Service (APHIS): papaya (two varieties), potato, squash, sugar beet, sweet corn, and tomato. Except for papaya and a small amount of sweet corn, transgenic fresh produce is currently unavailable to American consumers. Fruits and vegetables for processing may be available very soon—perhaps by fall 2006—as seed has been released to contract growers. (Hagen, 2006) The European Union is debating the question of permitting transgenic crop production alongside its well-established organic production in order to avoid World Trade Organization (WTO) sanctions against trade barriers. India is conducting field trials of

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Table 1.
Acreage planted to transgenic varieties, as percentage of total corn, soybeans, cotton acreage by state. USDA/NASS, June 30, 2005.

	Corn	Soybeans	Cotton
Arkansas		92	96
California			53
Georgia			95
Illinois	36	81	
Indiana	26	89	
Iowa	60	91	
Kansas	63	90	
Louisiana			95
Michigan	40	76	
Minnesota	66	83	
Mississippi		96	96
Missouri	55	89	
Nebraska	60	91	
North Carolina			95
Ohio	18	77	
South Dakota	83	95	
Texas			63
Wisconsin	46	84	
Other states	52	84	91
US	52	87	79

The Benbrook Report: Genetically Engineered Crops and Pesticide Use in the United States: 1996–2004

The major genetically engineered (GE) crop varieties commercialized since 1996 in the United States have been designed to help control a damaging class of insects and simplify herbicide-based weed management systems. Over the first nine years of commercial use, 670 million acres of crops expressing GE traits have been planted, or about 23 percent of the total 2,970 million acres of crops harvested across the country during this period.

Crops engineered to tolerate applications of herbicides, or so-called "herbicide-tolerant" crops (HT), account for the largest share of GE acres. About 487 million acres have been planted since 1996, or 73 percent of total GE crop acres. Herbicide-tolerant soybeans are the most widely planted GE crop technology and account for more than half the total acres planted to GE varieties since 1996. The vast majority of HT crops are engineered to tolerate glyphosate (trade name "Roundup," or referred to as "Roundup Ready"), the herbicide introduced to the market in 1972, by Monsanto.

Corn and cotton have been genetically engineered to express the bacterial toxin *Bacillus thuringiensis*, or Bt. This transgenic trait allows plants to manufacture within their cells a crystalline protein that is toxic to most Lepidopteran insects (moths and butterflies). Some 183 million acres of Bt transgenic corn and cotton have been planted since 1996, representing 27 percent of total GE crop acreage. (Benbrook, 2004)

transgenic maize (corn), mustard (oilseed crop), sugarcane (ethanol production), sorghum (ethanol and animal feed), pigeonpea, chickpea, rice (staple food grain), tomato, brinjal (eggplant or aubergine), banana, papaya, soybean, and medicinal plants. China anticipates commercializing transgenic rice varieties by 2008. (Dansby, 2006)

The top five countries growing transgenic crops in 2005, according to The International Service for the Acquisition of Agro-Biotech Applications (ISAAA) were the United States, Argentina, Brazil, Canada, and China. (See Table 2.) Fourteen countries were ranked in the first tier as major adopters of the technology. (ISAAA, 2006)

A checklist to aid prospective U.S. growers of transgenic crops in interpreting conditions imposed by the agribusiness licensee, including company technology agreements, is published online by RAFI-USA (*www.rafiusa.org*). (Moeller and Sligh, Farmers' Guide, 2004)

What Are Transgenic Crops?

No uniformly accepted definition of biotechnology exists, according to the National Center for Agricultural Law Research and Information (NCALRI) (*www.aglawcenter.org*). The center provides several definitions and commentary.

Under the broadest definition, the use of biological sciences to develop products—conventional plant and animal breeding techniques, conducted since the dawn of civilization—fall under biotechnology. In the popular press, biotechnology generally refers to newly-developed scientific methods used to create products by altering the

Table 2.
Global Status of Commercialized Transgenic Crops. 2005.

Rank	Country	Area (mil. Ha/A.)	Crop
1	USA	49.8/723.0	Soybean, maize (corn), cotton, canola, squash, papaya
2	Argentina	17.1/42.2	soybean, maize, cotton
3	Brazil	9.4/23.2	soybean
4	Canada	5.8/14.3	canola, maize, soybean
5	China	3.3/8.2	cotton
6	Paraguay	1.8/4.4	soybean
7	India	1.3/3.2	cotton
8	So. Africa	0.5/1.2	maize, soybean, cotton
9	Uruguay	0.3/.7	soybean, maize, cotton
10	Australia	0.3/.7	cotton
11	Mexico	0.1/.2	cotton, soybean
12	Romania	0.1/.2	soybean
13	Philippines	0.1/.2	maize
14	Spain	0.1/.2	maize
15	Colombia	<0.1/.2	cotton
16	Iran	<0.1/.2	rice
17	Honduras	<0.1/.2	maize
18	Portugal	<0.1/.2	maize

1 ha = 2.47 a. (results rounded to .0) genetic makeup of organisms and producing unique individuals or traits that are not easily obtained through conventional breeding techniques. These products are often referred to as transgenic, bioengineered, or genetically modified because they contain foreign genetic material. Agriculture is one of the first industries radically affected by this new technology on both a fundamental production level and a legal level. (NCALRI, 2000)

The focus of this publication is on crop varieties created through transgenic modification, or genetic modification (GM). The products of transgenetic engineering are often called genetically modified organisms, or GMOs. All these terms refer to methods by which biologists splice genes from one or more species into the DNA of crop plants in an attempt to transfer chosen genetic traits. The method is known as recombinant DNA technology.

Genes are segments of DNA that contain information that in part determines the end function of a living organism. Genetic engineers manipulate DNA, typically by taking genes from one species—an animal, plant, bacterium, or virus—and inserting them into another species, such as an agricultural crop plant. An intermediate organism or virus can be used to "infect" the host DNA with the desired genetic material. Microparticle bombardment technology is also widely used to deliver exogenous nucleic acids (DNA from another species) into plant cells. The desired genetic material is precipitated onto micron-sized metal particles and placed within one of a variety of devices designed to accelerate these "microcarriers" to velocities required to penetrate the plant cell wall. In this manner, transgenes can be delivered into the cell's genome. New DNA can also be inserted into a host cell using electroporation, in which a jolt of electricity is applied to cells to create openings in the plasma membrane that surrounds a cell. A (typically antibiotic-resistant) marker gene is included in the package to verify degree of effectiveness in introducing the foreign DNA. Gene stacking is becoming more common, adding a whole array of traits at once into the host organism. (Stierle, 2006)

Steps in electroporation and other methods of gene transfer

Steps in electroporation and other methods of gene transfer:

1) The DNA sequence for the gene that will be altered is identified and obtained from a donor organism (bacterium). This can be done by referring to known information pertaining to the sequence of the gene which is to be selected, followed by the removal of the gene from the donor organism.

2) The desired gene is removed from the donor organism through the use of site-specific enzymes known as restriction enzymes.

3) The desired gene is then subject to polymerase chain reaction (PCR), a method to amplify DNA and produce a workable amount of the gene.

4) Once acquired, there are several ways to transfer the donor gene into the cells of the target organism. In rice, a somewhat advanced process is utilized. This process is electroporation, wherein special wall-denaturing enzymes remove the plant cell wall. The cells become protoplasts, which are plant cells stripped of the cell wall but still encapsulated in the cellular membrane. In the next step of electroporation, a very high voltage electric charge is sent through the protoplast-containing solution. This charge causes the membrane to temporarily deteriorate, forming small pores. Through these temporary pores, the donor gene's DNA is injected. The DNA is injected in the form of transfer plasmids that migrate to the chromosome and become incorporated in the plant's DNA. Shortly after the charge and injection, the cell membrane reforms. The cell wall also reforms in a reverse process.

5) The newly altered cells are then placed in a culture to reproduce the unique cell types that compose the organism.

6) The resulting cells are then transferred to a regular growth environment where the newly incorporated gene will be expressed. (Bromley, no date)

The whole process can be illustrated by its application in the engineering of transgenic rice, using electroporation.

With the advent of genetic engineering of plants around 1983, it appeared that transgenic manipulation might benefit and even revolutionize agriculture. The transfer of desirable genetic traits across species barriers offered potential promises to solve problems in the management of agricultural crops, provide new possibilities to improve human and animal health, and provide a new revenue stream for farmers through contract production of pharmaceutical and industrial crops. (ESCOP/ECOP, 2000)

Potential environmental benefits included reduced toxic pesticide use, improved weed control resulting in less tillage and soil erosion, and water conservation. Furthermore, the new technology promised increased yields.

Transgenic crops were also patentable. Technology agreements or engineering would insure that seed could not be saved over for planting the next year. The developer's intellectual property rights were thereby protected, which offered the potential to increase profits and theoretically garner a monopoly over the transgenic seed supply.

Unintended Effects

Current methods of gene transfer are not precise. While scientists can control with relative exactness the "trait gene" (or its synthesized analog) to be inserted into a host plant genome, they cannot entirely control its location, nor the number of copies that get inserted. Location of genetic material is important because it controls the expression of biological traits, just as genes themselves do. Also, inserted DNA frequently contains multiple stacked genes for different traits (eight in the New Leaf potato), increasing chances of undesirable interactions.

A common and unpredictable occurrence is "silencing" of either the inserted genetic material or adjacent native genes. Present scientific knowledge is still a long way from being able to precisely control the traits the host plant will express and to guarantee genetic stability in subsequent generations. (Ryan and Ho, 2001) This potential for instability can lead to unpredictable and undesirable effects, examples of which include plant infertility, production of toxins and allergens, and reductions in yield and plant fitness. The transgenic seed industry consistently counters that since genes from no known allergens are incorporated, adequate care has been taken to guard against this contingency. (USDA/OIG, 2005)

Transgenetic engineers who rely on the simple model of gene expression—the position that one gene equals one effect—harbor an outdated interpretation of genetic theory, and one that could have serious implications. Pleiotrophy is the understanding that one gene may control multiple traits in an organism. Pleiotrophy multiplies the uncertainty surrounding transgenic crops. A gene identified as controlling a desirable trait may in fact control multiple traits in a variety of ways. Pleitrophy is common, and the interactions of genes with each other and with the environment add complexity. To accurately predict the effects of new genetic combinations is nearly impossible. The introduction of a novel life form into an ecology can trigger effects perhaps too great to be understood during our time. While it is true most mutations don't survive, those that do can profoundly affect human and other life forms.

Potential for instability can lead to unpredictable and undesirable effects.

For instance, transgenic soy strains appear to exhibit unintended effects. Field observations reported to the University of Georgia (New Scientist, 1999) and University of Missouri (UM press release, 2001) noted physiological problems affecting yields. Research published by University of Arkansas scientists in 2000 noted that glysophate disrupts the nitrogen fixation process in Roundup Ready soy. (King et al., 2001)

The current marker and promoter genes of choice also may create new hazards. The antibiotic-resistant marker genes carry the potential to increase the variety of bacteria resistant to antibiotics. (Sheldon, 1993) The viral promoter genes could combine with other infecting viruses, or be scrambled by the plant, to create new viral proteins.

The cauliflower mosaic virus (CaMV) is a very powerful promoter and is commonly used. The CaMV can potentially cause the inserted DNA package to be expressed out of proportion with the rest of the genetic code. When inserted with a particle gun, the CaMV promoter can jump out of the DNA package and land somewhere else in the host genome, causing disruption. The bacterial and viral vector genes could recombine to form active pathogens—either new ones, or old ones with renewed virulence, or with broader host specificity. (Stierle, 2006)

The ESCOP and ECOP report mentioned in the Introduction, while advocating and offering specific advice for an extensive education campaign in support of biotechnology, at the same time called for research studies to be carried out on several key safety issues raised by the public. An 18-member Biotechnology Implementation Task Force convened and issued an update in July 2001. However, nothing more has been heard from this committee. (ESCOP/ECOP, 2000) (See full text of the initial report at *www.escop.msstate.edu/committee/agbiotech.edu*.)

A retooled gene in Endless Summer tomatoes controls ripening to give better flavor and shelf-life. Photo by Jack Dykinga, USDA ARS.

A main regulating agency for transgenic technology in the U.S. is the Animal and Plant Health Inspection Service (APHIS), a division within the Department of Agriculture. Rather than conduct safety studies, APHIS appears to accept risk-management tools such as "performance-based regulatory standards" and "science-based risk assessment policies and procedures." This approach allows for an acceptable level of possible collateral damage, as long as it is far enough down the road. (USDA/OIG, 2005)

Each piece of the inserted gene package described above carries with it the potential to disrupt non-target portions of the host plant's DNA, to create instability in the new genetic construct, or to result in unpredictable combinations that can create new substances, viruses, or bacteria. What this adds up to is the possibility, again, of unintended effects—particularly in subsequent generations of the engineered plant. To date, no known replicated studies have been conducted that confirm or disprove potential long-term effects on human health. No known mechanism was proposed or included to identify undesirable side effects of the engineering process.

A December 2005 USDA assessment of APHIS protocols for monitoring GE trial crops criticized oversight lapses. APHIS countered that it was relying on an accepted risk/benefit assessment process, while USDA took the position that oversight should be strengthened, on the assumption there is significant risk—until the new technology has been proven safe beyond doubt.

Commercial Transgenic Crops and Their Traits

While increased yields and improved nutritional value are among the promised benefits of transgenic crops, most now planted worldwide are designed either 1) to survive exposure to certain herbicides (called herbicide-tolerant, or HT), or 2) to kill certain insect pests (called pesticidal or insecticidal). The transgenic tomato was designed for long shelf life. It is unclear whether the increased beta-carotene in transgenic "Golden Rice" (derived from the daffodil) is in a usable form for human nutrition, especially in the absence of dietary fats and proteins. (Grains of Delusion, 2001)

Transgenic herbicide-tolerant crops have been altered to withstand being sprayed with broad-spectrum herbicides, with the idea that one application will take care of most types of weeds without killing the crop. Insecticidal crops contain genes of the soil bacterium *Bacillus thuringiensis* (Bt). These Bt genes cause the plants to produce a chemical toxic to the European corn borer, the cotton bollworm, and other caterpillars. (Caterpillars are the larvae of insects in the Lepidoptera order, which includes moths and butterflies.)

As of 2005, about 87 percent of world transgenic acreage was in the U.S. (See Table 2.) Herbicide-tolerant crops accounted for about three quarters of the acreage planted, worldwide, to genetically engineered crops in 2005. Pesticidal crops, or a combination of pesticidal and herbicide-tolerant crops, accounted for most of the remaining acreage. Acreage devoted to crops with stacked genes intended to express a variety of traits is increasing. (USDA/NASS, 2005)

With an overwhelming amount of U.S. commodity program crop acreage devoted to transgenic versions, seed for conventional varieties is becoming scarce for those who choose not to plant transgenic crops. Traditional seed scarcity can affect farmers who wish to return to non-transgenic corn, soya, or cotton. (Holden, 2002) Cotton seed is controlled by two large suppliers working with a large public research institution. Development of the non-transgenic organic/specialty cotton sector, which accounts for the 37 percent non-transgenic cotton acreage in Texas (Table 1), has been hampered by concerns about cross-pollination and boll-weevil control. Soybeans and corn (often planted in rotation in the Upper Midwest) cover the most transgenic acres. There may be some new evidence that field workers working with Bt cotton are developing allergic reactions. (Bernstein et al., 1999)

One other large-acreage North American transgenic crop is canola (a low erucic acid form of European rapeseed). Canola is a major oilseed crop in Canada, but only a minor crop in the U.S. However, until recently, it was thought that acreage of both canola and rapeseed would increase in the near future in the Pacific Northwest. On May 9, 2006, a proposed large production facility at Gray's Harbor, Washington, announced that it would produce biodiesel from Asian palm oil, thus bypassing the "seed crushing hassles" of canola/rapeseed. (Montana Department of Environmental Quality, 2006)

Proposals to plant substantial acreages of canola and rapeseed (*Brassica napus*, *B. rapa*)—much of it transgenic varieties—in Oregon's Willamette Valley to produce raw material for biodiesel production caused considerable concern among small-acreage vegetable seed producers. A preliminary 2006 Oregon State University Extension study predicted a high potential for gene flow between *B. napus* canola and other *B. napus* crops (rutabaga and Siberian kale). Likewise, *B. rapa* rapeseed holds the potential for gene flow with its closely related vegetable crops (Chinese cabbage, pai-tsai, mizuna, Chinese mustard, broccoli raab, and turnip). Potential for crossbreeding between the two oilseed crop types was rated high, as well. Potential of crossbreeding with wild (*Raphanus raphanistrum*) and cultivated (*R. sativum*) forms of radish was considered low. More study was called for regarding outcrossing of canola with *B. oleracea* vegetables (cabbage, cauliflower, Brussels sprouts, kohlrabi, collards, and kale).

Oregon Extension concluded that "genetically modified canola [and rapeseed]

Table 3.
Percentages of U.S. 2005 crop acreage planted to insecticidal, herbicidal, and stacked-gene varieties.

	Insect resistant	Herbicide resistant	Stacked-gene
Soy	0	87	0
Corn	26	17	9
Cotton	18	27	34

present the greatest risk to vegetable crucifer seed crops.... The presence of the gene would make the seed crop unsuitable for markets that have strict tolerance on GMO contamination"—i.e., organic, identity preserved (IP), and European exports. Furthermore, "transgenes are relatively easy to detect at very low levels, so it is likely that their presence could be detected even if only a few interspecific hybrids were found in a vegetable seed lot." (Myers, 2006)

While acknowledging the risks to the producers of the nation's garden seed crops located in the Willamette Valley, researchers suggested that the vegetable seed producers could pack up and move. (Myers, 2006)

Most transgenic cotton is herbicide tolerant, though some varieties have the Bt trait; transgenic canola is herbicide-tolerant. The first transgenic wheat, initially planned for commercial introduction in 2003, is Roundup-tolerant. On May 10, 2004, Monsanto announced that it was discontinuing all research and field trial activities on Roundup-Ready wheat. After seven years of development, the release said, efforts to win over farmers and the international wheat market had failed.

A 2005 study published by the Western Resource Council showed that introduction of genetically modified wheat would lower income for wheat growers and the wheat industry. The report projects costs per bushel and per acre for farmers adopting Roundup-Ready wheat and for non-adopters under best-case and worst-case scenarios. Either way, farmers were projected to lose money from introduction and use of the Roundup-Ready wheat. (Benbrook, 2005)

Other traits engineered into commercial transgenic varieties include disease resistance, high pH tolerance, and several nutritional, taste, texture, and shelf-life characteristics (BIO, 2000)—primarily through gene stacking.

In the absence of transgenic labeling, the average U.S. consumer may not realize that ingredients derived from transgenic corn, soya, and oilseed are in 70 percent of the foods found in U.S. retail food outlets. Most prevalent is high-fructose corn syrup, which is replacing other sweeteners in a wide variety of mass-produced food products. The Biotech Industry Organization agrees that transgenic oils and ingredients derived from corn and soya are pervasive in conventional processed foods. Now that transgenic horticultural crops are in the marketplace, no one will know for sure—in the absence of labeling—whether fresh produce or processed shelf products contain engineered crops.

Five years ago introduction of transgenic fresh produce appeared imminent. Winter squash and a limited amount of sweet corn are now being retailed. However, after the Flavr-Savr® tomato was withdrawn and Starlink® feed corn caused a recall of taco shells, the subsequent paths of crops such as tomatoes, potatoes, sunflowers, peanuts, and sweet peppers diverged. Field trials were conducted from 1993–2001 on transgenic peanuts, all in the U.S. Field trials were conducted from 1993–2002 on sunflowers—in Australia, three European countries, and the U.S. Sweet bell peppers have been joined by rice, alfalfa, cabbage, carrots, cauliflower, sweet corn, cucumber, lettuce, mustard—and most recently, eggplant—on the list under development for

Transgenic Potato in the U.S.

More than 700 field trials of transgenic Bt potatoes were conducted in the U.S. from 1989–2002 by a single company. In 1996 Bt potatoes were made available to commercial growers, but after 2000 the Bt potato program was abandoned due to lack of consumer acceptance. Large fast food chains, snack food manufacturers, and potato processing conglomerates eliminated transgenic potatoes from their products. There are no other types of transgenic potatoes currently approved for sale in the U.S. *www.truefoodnow.org/crop/pipeline_rdfruit.html* commercial release. Transgenic fruits for which field trials are currently underway (some in the U.S.) are apples, cherries, cranberries, grapefruit, kiwi, pears, persimmons, pineapple, plum, and strawberries. Transgenic papaya, raised in Hawaii, has been commercialized for several years, and plum has recently been deregulated by APHIS. (Plum is, of course, the source of prunes.)

One variety of transgenic flax was approved in the U.S. in 1999, but transgenic flax is reportedly not being grown because of consumer resistance and market rejection. Flax seed oil and flax seed are popular nutraceutical products. (*www.truefoodnow.org/crop/pipeline_rdfruit.html*)

Transgenic rice trials in Missouri were halted by public protests. So far Iran is the only known country producing transgenic rice for human consumption. (See Table 2.)

Despite indications in 2002 that lack of public acceptance of transgenic food would cause transgenic firms to change course, it has turned out that transnational corporations have changed tactics—conducting trials overseas, keeping U.S. trials strictly secret (perhaps even from regulatory oversight by APHIS). The companies also lobby industry groups, such as the wheat boards, and seek to develop indirect markets such as processing aids and minor ingredients. Transgenic processing aids—enzymes and ingredients used to improve the color, flavor, texture, and aroma of manufactured foods—and preservatives, stabilizers, vitamin additives, and a vast number of minor ingredients are currently being derived from transgenic corn or soy. (Non-GMO Source, 2002)

The industry currently takes the position that the public has been consuming highly processed, transgenic foods for several years and that this large-scale experiment with the American food supply has been a success. Corn, oilseeds, cotton, and wheat are the North American crops with the most acreage and profit potential. For a more complete list of current and future commercial transgenic crops and their traits, see the APHIS list (Appendix 1).

Unresolved Issues of Concern

Unresolved issues in transgenic agriculture:

- Food safety
- Farm management
- Crop yield, costs, and profitability
- Marketing and trade
- Organic industry impacts
- Influence on public research
- Industry concentration and farmers' right to save seed
- Regulation of transgenic crops and apportionment of liability

Many disturbing unanswered questions remain about transgenic crops and their potential benefits, costs, and risks. In fact, according to an independent survey of research data on transgenic crops, conducted by the Winrock Foundation's Henry A. Wallace Center for Agricultural and Environmental Policy, "The varieties and uses of genetically altered crops have grown much more rapidly than our ability to understand them." This study reveals that only four percent of total federal agricultural biotech funding is dedicated to environmental assessment. (Wallace Center Report, 2001)

It should also be noted that there is even less research dedicated to human and animal health impacts of the technology.

Issues Facing Farmers and Ranchers

Since 2001 ecological risks of transgenic crops have become evident.

Flow to Neighboring Crops and to Related Wild Species

Gene flow from transgenic fields into conventional crops and related wild plants has occurred. This issue is of special

Pharmacrops

After the year 2000, reorganizations in the agrichemical/pharmaceutical industry led to a new emphasis on development of bioengineered products for enhancement of human and animal health. Between 1999 and 2002, 315 trials of pharmaceutical crops were conducted in the U.S., and such trials are ongoing. Corn is by far the most popular pharmacrop, accounting for more than two-thirds of the biopharm plantings. Other crops engineered for biopharmaceutical production include soybeans, rice, barley, wheat, canola, and tobacco.

Kentucky farmers report that transgenic tobacco has become the long-sought replacement crop after the tobacco buyout. Some was being trialed as a source of an AIDS medication. As of 2001, biopharm field trials had been conducted on at least 900 acres, probably closer to 1,600. The exact figure is not known because the USDA classifies these field trials as "confidential business information." The December 2005 Office of Inspector General (OIG) report criticized the regulatory agency charged with monitoring company field trials for lax reporting and inadequate monitoring, especially of "high-risk pharmaceutical and industrial crops" and called for "science-based risk assessment." (USDA/OIG, 2005)

concern to farmers because of the potential to cause herbicide resistance. For example, in western Canada, three different herbicide-resistant canola varieties have cross-pollinated to create canola plants that are resistant to all three types of herbicide. This new triple resistance has turned volunteer canola into a significant weed problem. (Ellstrand, 2001)

Gene flow from transgenic crops to wild relatives causes wild plants to acquire traits that improve their fitness, turning them into "super weeds." For example, jointed goatgrass—a weedy relative of wheat—can acquire the herbicide-tolerant trait of Roundup Ready wheat, and can therefore thrive in crop fields unless applications of other herbicides are made. Frank Young and his colleagues at Washington State University found that imidazolone-resistant wheat (not a transgenic variety) outcrossed to goatgrass in one season. (Stierle, 2006) Other traits that wild plants could acquire from transgenic plants that will increase their weediness are insect and virus resistance. (Ervin et al., 2001) Alfalfa, a popular hay crop, can easily cross with black medic, an invasive species prevalent in the western U.S. The Federal Register of June 27, 2005, announced that genetically modified alfalfa was unrestricted and that seed has been released for sale to farmers. (Moore, 2005; Non-GMO Source, 2005)

The Biotechnology Industry counters that resistant weeds can be controlled by "other herbicides." Research done at Iowa State University's Leopold Center found that the increased cost negates any advantage to the farmer of using transgenic seed. (Benbrook, 2001)

Because of potential effects on pest management, crop marketability, and liability, more research needs to be done to determine the conditions under which gene flow from transgenic plants is likely to be significant.

Pesticide Resistance in Insect Pests

Bacillus thuringiensis, or Bt, has been widely used as a microbial spray because it is toxic only to caterpillars. In fact, it is a pest management tool that organic farmers partially depend on—one of the few insecticides acceptable under organic rules. Unlike the commercial insecticide spray, the Bt engineered into transgenic crop plants is reproduced in all, or nearly all, the cells of every plant, not just applied on the plant surface for a temporary toxic effect. As a result, the possibility that transgenic Bt crops will accelerate development of pest resistance to Bt is of serious concern. Such resistance would remove this valuable and environmentally benign tool from the pest control toolbox of farmers and forest managers. For more on Bt pest resistance, see Pest Management at the Crossroads, *www.pmac.net/ge.htm.*

Antibiotic Resistance

As described in the earlier section on how gene transfer is accomplished, the use of antibiotic-resistant marker genes for the delivery of a gene package into a recipient plant carries the danger of spreading antibiotic-resistant bacteria. The implications for creation of antibiotic-resistant diseases are disturbing. Research is needed on antibiotic resistance management in transgenic crops. (ESCOP/ECOP, 2000) The European Commission's new rules governing transgenic crops stipulated phasing out antibiotic-resistant marker genes by the end of 2004. Because of potential effects on pest management, crop marketability, and liability, more research needs to be done to determine the conditions under which gene flow from transgenic plants is likely to be significant. By the end of 2005 no such research was underway and implementation of the EU rule has been complicated by imminent publication of a WTO ruling against EU trade restrictions on transgenic crops. The ruling is certain to be appealed. (Kiplinger, 2006)

Effects on Beneficial Organisms

Evidence continues to increase that transgenic crops—either directly or through practices linked to production—are detrimental to beneficial organisms. New studies show that Bt crops exude Bt in concentrations high enough to be toxic to some beneficial soil organisms. University of Arkansas agronomists found impaired "root development, nodulation, and nitrogen fixation" in Roundup-Ready soy. (King et al., 2001) Disruption of beneficial soil organisms can interfere with plant uptake of phosphorus, an essential plant nutrient. (Massey, 2000) Beneficial insects that prey on insect pests can be affected by insecticidal crops in two ways. First, the Bt in transgenic insecticidal crops has been shown in some laboratory studies to be toxic to ladybird beetles, lacewings, and monarch butterflies. (Ervin et al., 2001) The extent to which these beneficials are affected in the field is a matter of further study. Second, because the insecticidal properties of Bt crops function even in the absence of an economic threshold of pests, Bt crops potentially can reduce pest populations to the point that predator species are negatively affected. (*www.pmac.net/ge.htm*)

Reduced Crop Genetic Diversity

As fewer and larger firms dominate the rapidly merging seed and biotechnology market, transgenic crops may continue the trend toward simplification of cropping systems by reducing the number and type of crops planted. In addition, seed-saving, which promotes genetic diversity, is discouraged. In Europe, seed-saving traditionally practiced by a majority of farmers has been heavily restricted through registration requirements and subsidy payments. To be certified, seed must exhibit "distinctiveness, uniformity, and stability," called "DUS registration." (Toledo, 2002) A traditional landrace can be held uncertifiable (and effectively outlawed by billings for royalties and denial of subsidy payments) by being declared insufficiently distinct from a variety described in the EU Catalogue of Common Varieties. In an interview, Nancy Arrowsmith, founder of Arche Noah, (Arrowsmith, 1987) noted that traditional European landraces and seed-saving practices are being squeezed out in Common Market countries.

> Seed legislation is quite restrictive. In order to be distributed, seeds have to be registered. There has to be extensive testing—up to seven years—and the registration fee is quite high. [Germany, Switzerland,] and all of the countries that belong to the Common Market have adopted what they call the Common Catalogue. Only the vegetable varieties listed in this Catalogue can be sold.
>
> In Austria [Arrowsmith's home] many varieties are protected. ... In the catalogue it will say that these cannot be reproduced in any way.

Transgenic crops may continue the trend toward simplification of cropping systems by reducing the number and type of crops planted.

Outlawing landraces by legislative fiat (most recently in Iraq) was thwarted in the U.S. by organizations like the Seed Savers Exchange, which mobilized support for strong protection of the rights of seed savers in Plant Variety Patent legislation passed in the late 1980s. Traditional open-pollinated varieties are still vulnerable to genetic contamination by cross-pollination.

Following is a brief discussion of some of the remaining risk issues.

Food Safety

Food safety issues, except as they impact domestic marketing and exports, are beyond the scope of this publication. Five years ago the major publicized concerns were environmental. Since then, the environmental community has stalled some transgenic crops. Food safety concerns include:

- Possibility of toxins in food
- Possibility of new pathogens
- Reduced nutritional value
- Introduction of human allergens
- Transfer of antibiotic resistance to humans
- Unexpected immune-system and genetic effects from the introduction of novel compounds

It is in part because of these concerns that domestic consumer demand for organically grown crops continues to increase. There are other marketing problems that reflect religious dietary and general religious (sometimes dismissed as "cultural") sensibilities, as well as ethical/philosophical concerns.

Farm Management Issues

The most widely planted transgenic crops on the market today can simplify short-term pest management for farmers and ranchers. In the case of herbicide-tolerant crops, initially farmers hoped to use a single broad-spectrum herbicide for all their crop weeds. It has turned out that they need more than one application in most seasons. By planting insecticidal crops, farmers can eliminate the need to apply pesticides for caterpillar pests like the European corn borer or the cotton bollworm, though they still have to contend with other crop pests.

While these crops offer simplified pest control features, they may complicate other areas of farm management. Farmers who grow both transgenic and conventional varieties of the same crop will need to segregate the two during all production, harvesting, storage, and transportation phases if they sell into differentiated markets or plan to save their own seed from the conventional crops. See the complete regulations for organic handling at *www.ams.usda.gov/NOP*.

To minimize the risk of gene flow from transgenic to adjacent conventional crop fields, federal regulations require buffer strips of conventional varieties around transgenic fields.

To minimize the risk of gene flow from transgenic to adjacent conventional crop fields, federal regulations require buffer strips of conventional varieties around transgenic fields. Different transgenic crops require different buffer widths. Because the buffer strips must be managed conventionally, producers have to be willing to maintain two different farming systems on their transgenic fields. Crops harvested from the buffer strips must be handled and marketed as though they are transgenic.

Planted refuges—where pest species can live outside fields of insecticidal and herbicide-tolerant transgenic crops—are also required to slow the development of weed and insect pest resistance to Bt and broad-spectrum herbicides. These refuges allow some individuals in the pest population to survive and carry on the traits of pesticide susceptibility. Requirements governing the size of refuges differ according to the type of transgenic crop grown, but a 2006 report in AgBioForum, based on a survey of Indiana farmers, states the requirements are misunderstood by farmers and routinely ignored. For some crops they are unworkable. (Alexander and Van Melior, 2005)

Farmers growing herbicide-tolerant crops need to be aware that volunteer crop plants the following year will be herbicide resistant. Such resistance makes no-till or direct-seed systems difficult because volunteers can't be controlled with the same herbicide used on the rest of the crop. In a no-till system that relies on the same broad-spectrum herbicide that the volunteer plants are resistant to, these plants will contaminate the harvest of a following conventional variety of the same crop—a situation farmers tend to avoid for two reasons. First, the contamination means a following conventional crop will have to be sold on the transgenic market. This leads to the second reason. If farmers grow and market a transgenic crop for which they do not have a technology agreement and did not pay royalty fees, they may face aggressive collection by the company that owns the transgenic variety. Hundreds of U.S. farmers have already been charged with "theft" of a company's patented seed as a result of contamination in the field. (Altieri, 2000)

Farmers growing insecticidal crops need to recognize that insect pressure is difficult to predict and may not warrant the planting of an insecticidal variety every year. In a year when pest pressure is low, the transgenic seed becomes expensive insurance against the threat of insect damage. (Hillyer, 1999)

Farmers growing transgenic crops need to communicate with their neighbors to avoid contaminating neighboring fields and to ensure that buffers are adequate. In Maine, farmers growing transgenic crops are now required by law to be listed with the state agriculture department, to help identify possible sources of cross-contamination when it occurs. The law also "requires manufacturers or seed dealers of genetically engineered plants, plant parts, or seeds to provide written instructions to all growers on how to plant, grow, and harvest the crops to minimize potential cross-contamination of non-genetically engineered crops or wild plant populations." (AgBioTech, 2001)

Farm management issues common to all transgenic crops include yield, cost, price, profitability, management flexibility, sustainability, market acceptance, and liability. Yield and profitability, as well as market acceptance, are discussed in separate sections below. Liability is discussed under regulation.

Crop Yield, Costs, and Profitability

Some farmers will get higher yields with a particular transgenic crop variety than with their conventional varieties, and some will get lower yields. Yield variability is related to many factors, including choice of the conventional analog of the transgenic variety, making it very difficult to analyze how any one feature impacts yield. Costs of various inputs are also constantly changing; and the ability of farmers to adjust to changing costs, particularly rapid changes, is limited and affects profitability.

However, some yield, cost, and profitability trends do appear to be emerging from the growing body of research data for transgenic crops. As noted in the Wallace Center report, Roundup Ready soybeans were designed simply to resist a particular chemical herbicide, not to increase yields. In contrast, Bt corn and cotton, by resisting insect pests, may result in higher yields from reduced pest pressure. (Wallace Center, 2001)

Yield: Herbicide Tolerant Crops—Soybeans, Cotton, Canola

Herbicide-tolerant soybeans appear to suffer what's referred to as "yield drag." Again, in some areas and on some farms this tendency of Roundup Ready soybean varieties to yield less than their comparable, conventional counterparts varies, but overall, they appear to average yields that are five to ten percent lower per acre. As described earlier, impaired root development, nodulation, and nitrogen fixation likely account for this yield drag. Drought conditions worsen the effects. The bacterium that facilitates nodulation and nitrogen fixation in the root zone is apparently sensitive to both Roundup and drought. University of Missouri scientists reported problems with germination of Roundup Ready soybeans in the 2001 crop year. (UM press release, 2001)

Farmers growing transgenic crops need to communicate with their neighbors to avoid contaminating neighboring fields and to ensure that buffers are adequate.

Yields of herbicide-tolerant cotton are reportedly not significantly different from those of conventional cotton. (Benbrook, 2001; Wallace Center 2001, summarizing research by Klotz-Ingram et al., 1999)

Herbicide-resistant transgenic canola varieties yield less on average than conventional canola varieties. Transgenic canola costs less than conventional canola to produce, but because of its higher yields, conventional canola returns more profit per acre. (Fulton and Keyowski, 1999)

Yield: Insecticidal Crops—Corn, Cotton

Insecticidal Bt corn and cotton generally yield higher "in most years for some regions" according to USDA Economic Research Service data from 1996 to 1998. Bt cotton, especially, outpaces yields of conventional cotton by as much as 9 to 26 percent in some cases, though not at all in others. Yield increases for Bt corn have not been as dramatic. (Fulton and Keyowski, 1999) Time will tell whether farmers can expect yield increases or decreases in the long run with these and other transgenic crop varieties.

Changes in Chemical Pesticide Use

One of the promises of transgenic technology is that it will reduce pesticide use and thereby provide environmental benefits while reducing farmers' costs. The herbicide-tolerant and insecticidal varieties are designed specifically to meet these goals.

Studies estimate a two to three percent decrease in U.S. pesticide use, but the effects vary widely by crop, region, and year. Increased future pesticide use resulting from the buildup of resistance to heavily used herbicides is a long-term concern (Ervin et al., 2001) acknowledged by the transgenic crop industry. Pesticide use depends on the crop and its specific traits; weather, severity of pest infestations; farm management; geographic location of the farm; and other variables. As a result, conclusions drawn by various studies analyzing pesticide use on transgenic crops remain controversial. According to the Wallace Center report, in a review of the data available up through 2000, crops engineered to contain Bt appear to have decreased the overall use of insecticides slightly, while the use of herbicide-resistant crops has resulted in variable changes in overall herbicide use, with increases in use of some herbicides in some places and decreases in others. (Wallace Center, 2001)

The crop for which studies are showing the largest decrease in pesticide use is Bt cotton, with Bt corn resulting in only small changes. Herbicide-tolerant cotton has also resulted in little change in herbicide use. (Ervin et al., 2001)

The data for herbicide-tolerant soybeans seems harder to interpret. A recent study of herbicide use data on Roundup Ready soybeans by Charles Benbrook, PhD, former executive director of the National Academy of Sciences Committee on Agriculture and now with the Northwest Science and Environmental Policy Center, concludes that the use of herbicides has actually increased because the weeds have become resistant to Roundup. (Benbrook, 2004) While another recent study by scientists in The Netherlands shows a decrease in herbicide use on transgenic soybeans, it is clear that weed resistance to Roundup may lead to increased herbicide use and to the need to shift to more toxic compounds in the future (Ervin et al., 2001), and this is acknowledged by the industry. American Soybean Association president Tony Anderson agrees that the developing resistance of weeds to herbicides such as Roundup is a problem. (Environmental News Service, 2001)

The Wallace Center report emphasizes the importance of ongoing monitoring of pesticide use data. If farmers abandon integrated pest management, which utilizes a variety of pesticide and cultural control methods, in favor of the simplified control offered by herbicide-resistant and insecticidal transgenic crops, then early findings of reduced pesticide quantities and toxicity may not hold over the long run. Refer to chapter one of the Wallace Center report (Wallace Center, 2001) for USDA pesticide use data comparisons between transgenic and conventional crops, broken down by crop.

Profitability

Farmers need to consider all the factors that determine profitability. No single factor can tell the whole story. Transgenic crop seeds tend to be more costly, and farmers have the added expense of a substantial per-acre fee charged by the owners of transgenic varieties. These costs have to be considered along with input cost changes—whether herbicide or insecticide use and costs go down, go up, or stay the same. Market price is another factor. Prices for some transgenic crops in some markets are lower than prices for comparable conventional crops, though rarely they are higher. Farmers need to watch the markets. Some buyers will pay a premium for a non-transgenic product, though as transgenic seeds find their way into conventional transportation, storage, and processing steams, these premiums may disappear along with confidence that "GMO-free" products are in fact truly free of engineered genes. Future availability of conventional seed is another issue. Once farmers try transgenic crops, they have reported becoming locked into the technology, as alternate conventional seed supplies dry up. Also the potential liability of transgenic plants coming up in a conventional planting the next year is important to farmers. Transgenic seed suppliers aggressively pursue legal cases against any farmer using transgenic seed without having a signed technology agreement.

Marketing and Trade

Buyer acceptance is a significant marketing issue for farmers raising transgenic crops. Farmers need to know before they plant what their particular markets will or won't accept. Since most grain handlers cannot effectively segregate transgenic from non-transgenic crops in the same facility, many companies are channeling transgenic crops into particular warehouses. Farmers need to know which ones and how far away those are.

Many foreign markets have tended to be more leery of transgenic products than domestic markets, although this may change. World Trade Organization (WTO) directives can force dropping of trade barriers, but consumer acceptance cannot be forced (when choice is possible). Africa is a special case, as authority to accept or reject transgenic products was retained by governments, and several have banned GMOs in any form—even relief grain shipments. India has now developed its own transgenic industry and is producing transgenic cotton, while actively resisting attempts by others to patent its indigenous crop genetics. Brazil, Argentina, and China rank among the top five countries in acreage of transgenic soybeans, maize, and cotton. Even two European countries—Spain and Romania—are producing transgenic crops for animal feed. (See Table 2.)

Brazil, Argentina, and China rank among the top five countries in acreage of transgenic soybeans.

Eighty-six countries and the European Union have agreed on implementation steps for the UN's Cartagena Protocol on Biosafety, which came into force in September 2003. A rigorous system for handling, transporting, packing, and identifying transgenic crops was part of the agreement. All bulk shipments of genetically engineered crops intended for food, animal feed, or processing are to be labeled "May Contain LMOs," (Living Modified Organisms) according to the UNEP. Major producers of transgenic crops, including Canada, Argentina, and the U.S., did not sign the protocol. (Agence France Presse, 2004)

Trade in transgenic livestock feed is more liberal than trade in transgenic human food.

The rapid and widespread dissemination of the Cry9C Bt transgene (StarLink), which is not approved for human consumption but was detected in tacos, shows how easily transgenic material can spread from animal feed to human food products. The widespread publicity has resulted in even further resistance on the part of buyers to purchasing transgenic products for human food. According to a report in Britain's *The Guardian*, "No new transgenic crops have been approved by the European Union (EU) since April 1998, and a defacto moratorium on further approvals has been in place since June 1999." (Osborn, 2001) However, trials of food crops already approved continued, and the European Union officially lifted its moratorium on the introduction of new transgenic crops in 2004, although during the debate over labeling and traceability regulations the moratorium remained in effect. (Evans, 2001)

If approved, the new regulations will complicate the export of U.S. farm products to the EU because the U.S. does not require traceability or labeling of transgenic crops.

Under the proposed new EU requirements, "all foods and animal feed derived from GMOs have to be labeled and, in the case of processed goods, records have to be kept throughout the production chain allowing the GMO to be traced back to the farm." (Evans, 2001) If approved, the new regulations will complicate the export of U.S. farm products to the EU because the U.S. does not require traceability or labeling of transgenic crops. Spain and Romania rank in the top 14 countries growing biotech crops. Both grow transgenic animal feed crops. Portugal, Germany, France, and the Czech Republic grow small amounts of feed corn (maize)—less than 10,000 hectares (24,700 acres), probably much less.

While the U.S. does not require mandatory labeling of processed food containing transgenic ingredients, the EU, Russia, Japan, South Korea, Taiwan, Australia, New Zealand, and Ecuador do have such requirements, as of 2001. (Schrade and Raabe, 2001) The degree to which the Cartagena protocol (Agence France Presse, 2004) will be implemented by other signatories (see above) is unknown. Because many domestic merchandisers of agricultural commodities do not segregate transgenic from conventional crop varieties, it is impossible for them and the farmers that supply them to serve these food markets.

Twenty percent of corn and 35 percent of soybeans produced in the U.S. are exported (USDA/AMS, 2006), and more than 80 percent of these crops are used in animal feed. Few, if any, animal feeding trials were carried out before transgenic crops were released. In 2005, grain exports were down 5 percent overall from the previous year and 26 percent at Gulf Coast ports (due to the hurricanes).

In contrast, in a dramatic increase from 2001, 45 percent of U.S. wheat is exported. (USDA/AMS, 2006) Exports to countries that are resistant to buying transgenic food—particularly Japan and European nations—are dropping, but being supplanted by increased demand from Nigeria and Iraq. (USDA/AMS, 2006) Because wheat producers are so dependent on exports, they have vigorously resisted introduction of the first transgenic wheat, originally slated for 2003, now on hold. The Japanese milling industry has made it clear that it does not want transgenic products. As a result, Monsanto promised not to introduce Roundup Ready wheat until Japan gave its approval. (Hord, 2001) North Dakota and Montana considered legislation that would place a state moratorium on the introduction of transgenic wheat. Recent federal regulation, under the Homeland Security Act, would nullify any such local or state food laws.

In addition to national and international policies on the use and importation of transgenic crops, processors and retailers in many countries have set their own corporate policies. Major retail chains in Europe and the U.S. have declared their commitment to avoiding the purchase of transgenic products, both feed and food. But, in the absence of labeling, most have been willing to accept a pervasive presence of transgenic corn, soy, and canola in processed products.

Although European Union rules effectively barring U.S. corn imports have been recently relaxed, since 1997 the European Union ban has cost American farmers access to a $200 million annual market (Shadid, 2001) and the U.S. government billions in agricultural price supports.

Organic Industry

Organic farmers face even bigger marketing and trade risks, since their buyers expect no transgenic contamination. Currently, organic production is process-oriented, not testing oriented—except for exports. The organic industry has a system for segregation, but recent tests for transgenic material in organic products demonstrate that it is not immune to contamination from conventional systems. (Callahan, 2001) New technologies can reliably detect minute amounts of transgenic material. (See Seed testing, below.) Published reports from Europe and the U.S. confirm a high degree of accuracy for detection methods. (Non-GMO Source, 2004) European export markets organic farmers might have enjoyed, and those that producers of non-GE conventional crops could have built upon, have proven unstable in the presence of possible transgenic contamination. In 2005 U.S. exports of agricultural products fell below imports, for the first time in 20 years.

Influence on Public Research

While transgenic crop varieties are generally the property of private corporations, those corporations often contract with public-sector agricultural research institutions for some of their development work. In fact, private investment in agricultural research, including germplasm development, has surpassed public investment in recent years. (ESCOP/ECOP, 2000) With this shift in funding priorities, the following questions become important: Is the private sector unduly influencing the public research agenda? Are corporations directing public research in socially questionable directions while research on, for instance, sustainable agriculture wanes? Are the outcomes of corporate-funded transgenic research and development by our public institutions equitable across the food and agricultural sectors? Is equity even a consideration of our public institutions when they accept this work?

When intellectual property rights (patents) apply to living organisms, making them private property, the free flow of

Seed testing for genetically modified traits

Selecting the appropriate test for seed will ultimately depend on the end use of the results. Are you looking for the absence or presence of a trait, or do you need quantitative data? The best approach to testing for genetically modified traits is to understand the ultimate use of the tests and then to talk with the laboratory or technologist that will be performing the test. The technologist will be able to describe the four types of tests commonly used by the seed industry to test for traits:

- Herbicide bioassay
- Immunoassay (ELISA, lateral flow strips)
- Electrophoresis (PAGE, IEF, starch-gel)
- Polymerase chain reaction (PCR)

The technologist can help you select the test that will best fulfill your needs. Five years ago, the Society of Commercial Seed Technologists (SCST) created an accreditation program for technologists in these four areas. The program ensures that the technologist is proficient in both the theory and practical application of the genetic purity tests currently utilized by the seed industry. Using a laboratory with a certified or registered genetic technologist ensures that GM tests are conducted by an experienced person. The SCST Genetic Technology Committee and working groups are extremely active in providing training and education to keep members up-to-date in this rapidly evolving area of seed testing.

Hall, Anita, executive director, Society of Commercial Seed Technologists, Inc. *www.seedworld.com/sw/index.cfm/powergrid/rfah=|cfap=/CFID/4091662/CFTOKEN/68435952/fuseaction/showArticle/articleID/6542* scientific information that has historically characterized public agricultural research is inhibited. What are the implications for the future of agriculture and society of the secrecy that now surrounds so much of what was formerly shared public knowledge? For a brief history of intellectual property rights as they apply to living organisms, see: *www.escop.msstate.edu/committee/agbiotec.pdf*

These and other questions need to be addressed by citizens and their public institutions. These issues are of particular concern to farmers and consumers who would benefit from research into alternative technologies that are less costly (in every way), less risky, and more equitable. Equity requires that the economic benefits and risks of technology be fairly distributed among technology providers, farmers, merchants, and consumers.

For long-term sustainability, farmers need research that focuses on farms as systems, with internal elements whose relationships can be adjusted to achieve farm management goals. (Union of Concerned Scientists, 2000) In contrast, transgenic crop research so far has focused on products that complement toxic chemical approaches to control of individual pest species. These are products that can be commercialized by large agribusiness or agri-chemical interests and that farmers must purchase every year. This research orientation only perpetuates the cost-price squeeze that continues to drive so many out of farming.

Industry Concentration and Farmers' Right to Save Seed

The broadening of intellectual property rights in 1980 to cover living organisms, including genes, has resulted in a flurry of mergers and acquisitions in the seed and biotech industries. According to the Wallace Center report, "Relatively few firms control the vast majority of commercial transgenic crop technologies."

These firms have strategically developed linkages among the biotechnology, seed, and agri-chemical sectors to capture as much market value as possible. However, these tightly controlled linkages of product sectors raise serious issues of market access, product innovation, and the flow of public benefits from transgenic crops. (Wallace Center, 2001)

Unlike Plant Variety Protection—which does not allow for the patenting of individual genes, but only of crop varieties—Intellectual Property Rights prohibit farmers from saving seed and undertaking their own breeding programs, and prohibit plant breeders from using the material to create new generations of varieties adapted to specific regions or growing conditions. (Guebert, 2001) The Intellectual Property Rights have recently been upheld by the U.S. Supreme Court, which relied on a 1795 General Patents statute.

By 2000, agri-chemical giants DuPont and Monsanto together owned 73 percent of the corn seed producers in the U.S. (Massey, 2000) Although some have recently been divested, this kind of corporate control and concentration raises the question of whether there remains enough competition in the seed industry for seed pricing to remain competitive. As additional concentration occurs, how affordable will seed—all seed, not just transgenic seed—

be for farmers? This question takes on added gravity as an increasing number of seed varieties become proprietary and seed production, especially for gardeners, is pushed out of California and Oregon into Nevada and Idaho. Farmers can't save proprietary seed for planting and so must purchase new seed every year. In addition, farmers choosing transgenic varieties must sign a contract with the owner of the variety and pay a substantial per-acre technology fee, or royalty.

The anticipated commercial introduction of transgenic wheat represents a dramatic shift in an industry in which farmers still widely save their own seed. As non-transgenic varieties become contaminated with transgenic ones, even those farmers who choose to stick with conventional varieties will lose the right to replant their own seed. This loss has already occurred in Canada's canola industry, with Monsanto winning its court case against farmer Percy Schmeiser for replanting his own canola variety that had become contaminated with Monsanto's Roundup Ready canola. (See article by E. Ann Clark, Plant Agriculture, University of Guelph, Ontario, at *www.plant.uoguelph.ca/faculty/eclark*)

The adoption of transgenic crop varieties has brought with it an increasing prevalence of contract production. While contract production can lead to increased value and reduced risk for growers, farmers are justified in their concern about their loss of control when they sign a contract with a private company. Issues associated with contract production of transgenic crops must be considered within the broader context of a sustainable agriculture to include ownership, control, and social equity.

Regulation of Transgenic Crops and Apportionment of Liability

Much of the controversy over transgenic crops, both internationally and in the U.S., is in part a result of how the U.S. regulates transgenic crops. The federal government has determined that the commercial products of agricultural biotechnology are "substantially equivalent" to their conventional counterparts and that therefore no new regulatory process or structure is needed for their review and approval.

Currently, three federal agencies regulate the release of transgenic food crops in the U.S.: the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (USDA–APHIS), the U.S. Environmental Protection Agency (EPA), and the U.S. Food and Drug Administration (FDA).

USDA–APHIS: APHIS looks at how a transgenic plant behaves in comparison with its unmodified counterpart. Is it as safe to grow? The data it uses are supplied largely by the companies seeking a permit for release of the new crop. Under "fast-track" approval, a process in place since 1997, companies introducing a crop similar to a previously approved version need give only 30 days' advance notice prior to releasing it on the market. According to the Wallace Center report, APHIS staff estimate that by 2000, 95 to 98 percent of field tests were taking place under simple notification rules rather than through permitting. (Wallace Center, 2001) The Office of Inspector General (OIG) report has called for much stricter tracking—in light of the industry shift to industrial and pharmacrops.

EPA: The EPA regulates the pesticides produced by transgenic crops, such as the Bt in Bt corn and cotton. It does not regulate the transgenic crops themselves. In contrast with its regulation of conventional pesticides, the EPA has set no tolerance limits for the amount of Bt that transgenic corn, cotton, and potatoes may contain. (Wallace Center, 2001)

FDA: The FDA focuses on the human health risks of transgenic crops. However, its rules do not require mandatory pre-market safety testing or mandatory labeling of transgenic foods. Initially, the U.S. regulatory process for transgenic food crops required product-by-product reviews. Now, however, to simplify and speed up the process, new products can be approved based on the

The adoption of transgenic crop varieties has brought with it an increasing prevalence of contract production.

experience gained in reviewing earlier products. According to the Wallace Center report, the implication is that "some crops might be approved, or disapproved, without actual field testing." (Wallace Center, 2001) The regulatory process, in fact, may not answer most questions about the environmental and human health risks of commercial production of these crops. (Advisory on Committee on Biotechnology, 2003)

Central to the policy of substantial equivalence is the assumption that only the end product of transgenic technology is of concern—not the process of genetic modification. Canada has adopted a similar approach. Europe and other U.S. trading partners, however, have taken a more conservative approach. They focus on the process of genetic modification—the source of many of the environmental and human health risks of greatest concern.

How these different approaches play out in reality can be summed up simply. The U.S. and Canada assume a product is safe until it is proven to carry significant risk; the European Union, which follows the "precautionary principle," assumes the same product may carry significant risk until it can be proven safe. The science used by the two approaches is not fundamentally different. The difference is in the level of risk the different societies and political systems are willing to accept. (ESCOP/ECOP, 2000)

Liability

Farmers who choose not to grow transgenic varieties risk finding transgenic plants in their fields anyway, as a result of cross-pollination via wind, insects, and birds bringing in pollen from transgenic crops planted miles away. Besides pollen, sources of contamination include contaminated seed and seed brought in by passing trucks or wildlife. Those farmers whose conventional or organic crops are contaminated, regardless of the route, risk lawsuits filed against them by the companies that own the proprietary rights to seed the farmer didn't buy. Likewise, farmers who grow transgenic crops risk being sued by neighbors and buyers whose non-transgenic crops become contaminated.

Because contamination by transgenic material has become so prevalent in such a short

Precautionary Principle

The principle of precaution was developed specifically for issues involving ethics and risk. It is described by Katherine Barrett, project director with the Science and Environmental Health Network, as: "… a process for decision-making under conditions of uncertainty. The principle states that when there is reason to believe that our actions will result in significant harm, we should take active measures to prevent such harm, even if cause-and-effect relationships have not been proven conclusively…. It has been invoked in many international laws, treaties, and declarations on a range of environmental issues including climate change, marine dumping of pollutants, and general efforts towards sustainability—[including the 2000 international Cartagena Biosafety Protocol on the transfer of 'living modified organisms'] … There is growing consensus that the precautionary principle has reached the status of international customary law." (Barrett, 2000)

The primary elements of the precautionary principle are identified by Barrett as:

1. Avoid harms to the environment that are "irreversible, persistent, bioaccumulative, or otherwise serious."

2. "Anticipate and prevent potential harms at the source," rather than relying on reactive measures of mitigation, clean-up, or compensation.

3. Recognize the limits of scientific knowledge and don't expect a full and conclusive understanding of potential consequences before taking precautionary action, especially when the potential consequences are long-term, unconfined, and broad-scale.

4. Shift the burden of proof to the developers of potentially hazardous technologies.

5. Finally, some versions of the precautionary principle include analysis of the costs and benefits of precautionary action, though cost-benefit analysis "is not a sufficiently robust decisionmaking framework to stand alone." (Barrett, 2000)

time, all farmers in areas of transgenic crop production are at risk. Insurance, the most common recourse for minimizing potential losses because of liability, is not available to the nation's farmers for this risk because insurance companies do not have enough experience for gauging potential losses.

Most of the farmers who have been accused by transgenic seed companies of illegally growing and harvesting their proprietary transgenic varieties have paid fines to the companies rather than go to court to defend themselves. One Canadian grower of non-transgenic canola, Percy Schmeiser, did go to court against Monsanto, and lost. The initial ruling required him to pay Monsanto the approximately U.S. $85,000 value of his crop and $13,000 in punitive damages. The amount was eventually reduced, upon appeal. This farmer's case has implications for other farmers, especially those who traditionally save their own seed for planting the next year's crop.

In another example, a Texas organic farm's corn, assumed to be GE-free, was purchased by a processor who made it into organic tortilla chips. Only after the product had been sold and shipped to European retailers was it discovered to be contaminated with transgenic corn. The processor had to recall its product at a cost of over $150,000. The processor chose not to sue the organic farmer, but could have. (Shadid, 2001) The retailer, in turn, apparently did not sue the processor. Had it done so, the liability for the retailer's loss could have fallen on both the processor and the farmer.

Until laws or legal precedent clarify the extent of farmer liability, farmers would do well to avoid making assumptions or claims about the purity of their non-transgenic products. (Some export crops, as well as Identity Preserved crops, are now being tested before shipping.) Furthermore, producers of transgenic crops need to take all possible precautions against spreading pollen and seed to their own and others' non-transgenic fields and markets. A full risk assessment and legal clarification of the distribution of liability among farmers, seed companies, grain handlers, processors, and retailers is needed before farmers can rest assured that transgenic crops won't result in lawsuits against them. For farmers who have adopted transgenic technology—and for those who have not—in the words of Brian Leahy, executive director of California Certified Organic Farmers, "This technology does not respect property rights." (Shadid, 2001)

In essence, farmers who grow transgenic crops on some of their fields, and farmers who grow none, risk bearing tremendous liability. This situation won't change until farmers either gain legal protection or stop growing transgenic crops entirely.

Implications for Sustainable Agriculture

In contrast to the ecological approach of sustainable agriculture, "the current generation of transgenic crops follows a pest management model like that employed for chemical pesticides—through interventions that are toxic to pests," the Wallace Center report points out. This "single-tool" approach is likely to fail in the long run because pests will successfully develop resistance that allows them to thrive. (Wallace Center, 2001)

Standard plant-breeding methods can potentially solve many of the same problems in agriculture that genetic engineers are working on, though there are areas in which genetic engineering can enhance traditional plant breeding. Armed with the map of an organism's genetic code, scientists can test which genes are in a plant to select more easily which ones to cross-breed. "Before we knew where the genes were, we were still breeding in the dark," according to Steven Briggs, head of genomics for Syngenta, a Swiss biotechnology giant, as quoted in the New York Times. (Pollack, 2001)

Gauging a Technology's Impact on Agricultural Sustainability

The sustainability of any agricultural technology can be gauged in part by answering a series of questions that emerge from

"This technology does not respect property rights."
–Brian Leahy, CCOF

the principles of sustainable agriculture. Farmers and ranchers can ask themselves these questions in the context of their own operations to help determine whether adoption of the technology will move them away from, or toward, increased sustainability.

1. Does the technology increase genetic diversity?
2. Does it maintain a positive balance of pests and predators?
3. Does it protect or enhance soil biota?
4. Does it decrease the quantity or concentration of toxins released into the environment?
5. Does it decrease soil erosion?
6. Does it protect non-target organisms?
7. Does it help protect natural habitats?
8. Does it reduce pest populations and viability?
9. Does it increase farmers' yields? Decrease farmers' costs?
10. Does it increase farmers' market control? Management flexibility? Time?
11. Does it provide benefits to consumers? Will consumers accept it?
12. Does it help citizens globally gain better access to food?
13. Does it protect the public's access to information and improve public trust in agriculture?

If the answer to any of the above questions is no, a cautious approach to the adoption of the technology in question would seem in the interest of agricultural sustainability.

Conclusion

Evelyn Fox Keller, author of *The Century of the Gene* (Fox, Keller, 2000) describes the scientific understanding of genetics that originated with the discovery of DNA in 1953, and on which the current generation of transgenic crops is still based:

> For almost fifty years, we lulled ourselves into believing that, in discovering the molecular basis of genetic information, we had found the "secret of life"; we were confident that if we could only decode the message in DNA's sequence of nucleotides, we would understand the "program" that makes an organism what it is.

Recent scientific discoveries no longer support this theory. Outdated as it has become, the view that each genetic message comes from a distinct gene continues to drive promises of feeding the world and curing incurable diseases—a view Keller calls a now "utterly fantastic premise." Keller, a professor of History and Philosophy of Science at Massachusetts Institute of Technology, insists that the most recent scientific understanding of genetics has more to tell us about biological organization than about how to modify individual traits. In fact, the new leading-edge biotechnology will strive to capture the benefits of genetic engineering without the costs, risks, and potential genetic instability.

Molecular biologists and breeders are beginning to utilize the emerging knowledge of gene location and function to guide them in the application of conventional and innovative breeding techniques that do not rely on a transgene with promoter and marker genes. (AgBioTech, 2001) This is good news for sustainable agriculture, which is based on understanding how natural systems work in order to fit human enterprises into them. According to Fred Kirschenmann, organic farmer and former director of Iowa State University's Leopold Center for Sustainable Agriculture, "The real benefit of genetics seems to be derived not from the manipulation of a few genes, but from our enhanced understanding of how nature works." (Kirschenmann, 2001)

Regardless of the future direction of transgenic technology, one thing remains certain: Many of the unresolved issues for farmers, ranchers, and the general public will not be settled through the use of biological or natural sciences alone.

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Appendices

Appendix 1

Petitions of Nonregulated Status Granted or Pending
by APHIS as of 3 February 2006
www.aphis.usda.gov/brs/not_reg.html

Abbreviations:

CMV-cucumber mosaic virus
CPB-colorado potato beetle
PLRV- potato leafroll virus
PRSV-papaya ringspot virus
PVY-potato virus Y
WMV2- watermelon mosaic virus 2
ZYMV-zucchini yellow mosaic virus

Petitions for Nonregulated Status Granted

Applicant Documents						APHIS Documents			
Petition	*Extension of Petition No.****	*Institution*	*Regulated Article*	*Transgenic Phenotype*	*Transformation Event or Line*	*Preliminary EA *****	*FR Notice*	*Risk Asses.*	*Final EA & Determination*
92-196-01p		Calgene	Tomato	Fruit ripening altered	FLAVR SAVR	92-196-01p_ea	92-196-01p_fr		92-196-01p_com
92-204-01p		Upjohn	Squash	WMV2 & ZYMV resistant	ZW-20	92-204-01p_ea	92-204-01p_fr		92-204-01p_com
93-196-01p		Calgene	Cotton	Bromoxynil tolerant	BXN	93-196-01p	93-196-01p_fr		93-196-01p_com
93-258-01p		Monsanto	Soybean	Glyphosate tolerant	40-3-2	93-258-01p	93-258-01p		93-258-01p_com
94-090-01p		Calgene	Rapeseed	Oil profile altered	pCGN3828-212/86- 18 & 23	94-090-01p	94-090-01p		94-090-01p_com
94-227-01p	92-196-01p	Calgene	Tomato	Fruit ripening altered	Line N73 1436-111	94-227-01p	94-227-01p_fr		94-227-01p_com
94-228-01p		DNA Plant Tech	Tomato	Fruit ripening altered	1345-4	94-228-01p_ea	94-228-01p_fr		94-228-01p_com
94-230-01p	92-196-01p	Calgene	Tomato	Fruit ripening altered	9 additional FLA-VRSAVR lines	94-230-01p	94-230-01p		94-230-01p_com
94-257-01p		Monsanto	Potato	Coleopteran resistant	BT6, BT10, BT12, BT16, BT17, BT18, BT23	94-257-01p_ea	94-257-01p_fr		94-257-01p_com
94-290-01p		Zeneca & Petoseed	Tomato	Fruit polygalacturonase level decreased	B, Da, F	94-290-01p	94-290-01p		94-290-01p_com
94-308-01p		Monsanto	Cotton	Lepidopteran resistant	531, 757, 1076	94-308-01p	94-308-01p		94-308-01p_com
94-319-01p		Ciba Seeds	Corn	Lepidopteran resistant	Event 176	94-319-01p	94-319-01p		94-319-01p_com
94-357-01p		AgrEvo	Corn	Phosphinothricin tolerant	T14, T25	94-357-01p	94-357-01p		94-357-01p_com
95-030-01p	92-196-01p	Calgene	Tomato	Fruit ripening altered	20 additional FLA-VRSAVR lines	95-030-01p	95-030-01p		95-030-01p_com
95-045-01p		Monsanto	Cotton	Glyphosate tolerant	1445, 1698				95-045-01p_com
95-053-01p		Monsanto	Tomato	Fruit ripening altered	8338				95-053-01p_com
95-093-01p		Monsanto	Corn	Lepidopteran resistant	MON 80100				95-093-01p_com
95-145-01p		DeKalb	Corn	Phosphinothricin tolerant	B16				95-145-01p_com
95-179-01p	92-196-01p	Calgene	Tomato	Fruit ripening altered	2 additional FLA-VRSAVR lines				95-179-01p_com
95-195-01p		Northrup King	Corn	European Corn Borer resistant	Bt11				95-195-01p_com
95-228-01p		Plant Genetic Systems	Corn	Male sterile	MS3				95-228-01p_com
95-256-01p		Du Pont	Cotton	Sulfonylurea tolerant	19-51a				95-256-01p_com
95-324-01p		Agritope	Tomato	Fruit ripening altered	35 1 N				95-324-01p_com
95-338-01p		Monsanto	Potato	CPB resistant	SBT02-5 & -7, ATBT04-6 &-27, -30, -31, -36				95-338-01p_com

Continued: *Petitions for Nonregulated Status Granted*									
Applicant Documents						**APHIS Documents**			
Petition	*Extension of Petition No.****	*Institution*	*Regulated Article*	*Transgenic Phenotype*	*Transformation Event or Line*	*Preliminary EA *** **	*FR Notice*	*Risk Asses.*	*Final EA & Determination*
95-352-01p		Asgrow	Squash	CMV, ZYMV, WMV2 resistant	CZW-3				95-352-01p_com
96-017-01p	95-093-01p	Monsanto	Corn	European Corn Borer resistant	MON809 & MON810				96-017-01p_com
96-051-01p		Cornell U	Papaya	PRSV resistant	55-1, 63-1				96-051-01p_com
96-068-01p		AgrEvo	Soybean	Phosphinothricin tolerant	W62, W98, A2704-12, A2704-21, A5547-35				96-068-01p_com
96-248-01p	92-196-01p	Calgene	Tomato	Fruit ripening altered	1 additional FLAVRSAVR line				96-248-01p_com
96-291-01p		DeKalb	Corn	European Corn Borer resistant	DBT418				96-291-01p_com
96-317-01p		Monsanto	Corn	Glyphosate tolerant & ECB resistant	MON802				96-317-01p_com
97-008-01p		Du Pont	Soybean	Oil profile altered	G94-1, G94-19, G-168				97-008-01p_com
97-013-01p		Calgene	Cotton	Bromoxynil tolerant & Lepidopteran resistant	Events 31807 & 31808				97-013-01p_com
97-099-01p		Monsanto	Corn	Glyphosate tolerant	GA21				97-099-01p_com
97-148-01p		Bejo	Cichorium intybus	Male sterile	RM3-3, RM3-4, RM3-6				97-148-01p_com
97-204-01p		Monsanto	Potato	CPB & PLRV resistant	RBMT21-129 & RBMT21-350				97-204-01p_com
97-205-01p		AgrEvo	Rapeseed	Phosphinothricin tolerant	T45				97-205-01p_com
97-265-01p		AgrEvo	Corn	Phosphinothricin tolerant & Lep. resistant	CBH-351				97-265-01p_com
97-287-01p		Monsanto	Tomato	Lepidopteran resistant	5345				97-287-01p_com
97-336-01p		AgrEvo	Beet	Phosphinothricin tolerant	T-120-7				97-336-01p_com
97-339-01p		Monsanto	Potato	CPB & PVY resistant	RBMT15-101, SEMT15-02, SEMT15-15				97-339-01p_com
97-342-01p		Pioneer	Corn	Male sterile & Phosphinothricin tolerant	676, 678, 680				97-342-01p_com
98-014-01p	96-068-01p	AgrEvo	Soybean	Phosphinothricin tolerant	A5547-127				98-014-01p_com
98-173-01p		Novartis Seeds & Monsanto	Beet	Glyphosate tolerant	GTSB77				98-173-01p_com
98-216-01p		Monsanto	Rapeseed	Glyphosate tolerant	RT73				98-216-01p_com
98-238-01p		AgrEvo	Soybean	Phosphinothricin tolerant	GU262				98-238-01p_com
98-278-01p		AgrEvo	Rapeseed	Phosphinothricin tolerant & Pollination control	MS8 & RF3				98-278-01p_com
98-329-01p		AgrEvo	Rice	Phosphinothricin tolerant	LLRICE06, LLRICE62				98-329-01p_com
98-335-01p		U. of Saskatchewan	Flax	Tolerant to soil residues of sulfonyl urea herbicide	CDC Triffid				98-335-01p_com
98-349-01p	95-228-01p	AgrEvo	Corn	Phosphinothricin tolerant and Male sterile	MS6				98-349-01p_com
99-173-01p	97-204-01p	Monsanto	Potato	PLRV & CPB resistant	RBMT22-82				99-173-01p_com
00-011-01p	97-099-01p	Monsanto	Corn	Glyphosate tolerant	NK603				00-011-01p_com
00-136-01p		Mycogen c/o Dow & Pioneer	Corn	Lepidopteran resistant phosphinothricin tolerant	Line 1507				00-136-01p_com
00-342-01p		Monsanto	Cotton	Lepidopteran resistant	Cotton Event 15985				00-342-01p_com
01-121-01p		Vector	Tobacco	Reduced nicotine	Vector 21-41				01-121-01p_com
01-137-01p		Monsanto	Corn	Corn Rootworm Resistant	MON 863				01-137-01p_com

Continued: *Petitions for Nonregulated Status Granted*

Applicant Documents						APHIS Documents			
Petition	*Extension of Petition No.****	*Institution*	*Regulated Article*	*Transgenic Phenotype*	*Transformation Event or Line*	*Preliminary EA *****	*FR Notice*	*Risk Asses.*	*Final EA & Determination*
01-206-01p	98-278-01p	Aventis	Rapeseed	Phosphinothricin tolerant & pollination control	MS1 & RF1/RF2				01-206-01p_com
01-206-02p	97-205-01p	Aventis	Rapeseed	Phosphinothricin tolerant	Topas 19/2				01-206-02p_com
01-324-01p	98-216-01p	Monsanto	Rapeseed	Glyphosate tolerant	RT200				01-324-01p_com
02-042-01p		Aventis	Cotton	Phosphinothericin tolerant	LLCotton25				02-042-01p_com
03-036-01p		Mycogen/ Dow	Cotton	Lepidopteran Resistant	281-24-236	03-036-01p_pea	03-036-01p _fr_pc_pet		03-036-01p_com
03-036-02p		Mycogen/ Dow	Cotton	Lepidopteran Resistant	3006-210-23	03-036-02p_pea	03-036-02p _fr_pc_pet		03-036-02p_com
03-155-01p		Syngenta	Cotton	Lepidopteran Resistant	COT 102	03-155-01p_pea	03-155-01p_ fr_pc_pet		03-155-01p_com
03-181-01p	00-136-01p	Dow	Corn	Lepidopteran Resistant	Glufosinate Tol-erant	TC-6275	03-181-01p_ pea	03-181-01p_fr_ pc_pet	03-181-01p_com
03-323-01p		Monsanto	Sugar Beet	Glyphosate Tolerant	H7-1	03-323-01p_pea	03-323-01p_ fr_pc_pet		03-323-01p_com
03-353-01p		Dow	Corn	Corn Rootworm Resistant	59122	03-353-01p_pea	03-353-01p_ fr_pc_pet		03-353-01p_com
04-086-01p		Monsanto	Cotton	Glyphosate Tolerant	MON 88913	04-086-01p_pea	04-086-01p fr_pc_pet		04-086-01p_com
04-110-01p		Monsanto & Forage Genet-ics	Alfalfa	Glyphosate Tolerant	J101, J163	04-110-01p_pea	04-110-01p _fr2_pc_pet		04-110-01p_com
04-125-01p		Monsanto	Corn	Corn Rootworm Resistant	88017	04-125-01p_pea	04-125-01p _fr_pc_pet		04-125-01p_com
04-229-01p		Monsanto	Corn	High Lysine	LY038	04-229-01p_pea	04-229-01p _fr_pc_pet		04-229-01p_com

Petitions for Nonregulated Status Pending

Applicant Documents						APHIS Documents			
Petition	*Extension of Petition No.****	*Institution*	*Regulated Article*	*Transgenic Phenotype*	*Transformation Event or Line*	*Preliminary EA *****	*FR Notice*	*Risk Asses.*	*Final EA & Determination*
03-104-01p		Monsanto & Scotts	Creeping bentgrass	Glyphosate Tolerant	ASR368		03-104-01p_fr_ pc_pet	03-104-01p_ra	
04-264-01p		ARS	Plum	Plum Pox Resistant	C5		92-204-01p_fr		
04-337-01p		University of Florida	Papaya	Papaya Ringspot Virus Resistant	X17-2		93-196-01p_fr		
04-362-01p		Syngenta	Corn	Corn Rootworm Protected	MIR604		93-258-01p		
05-280-01p		Syngenta	Corn	Thermostable alpha-amylase	3272		94-090-01p		

*** Extension of Petition Number:

Under 7CFR 340.6(e) a person may request that APHIS extend a determination of non-regulated status to other organisms based on their similarity of the previously deregulated article. This column lists the previously granted petition of that degregulated article.

**** Preliminary EA:

The Environmental Assessment initially available for Public comment prior to finalization.

Appendix 2

Excerpt: Agricultural Biotechnology: Critical Issues and Recommended Responses from the Land-Grant Universities—A report to the Experiment Station Committee on Organization and Policy (ESCOP) and the Extension Committee on Organization and Policy (ECOP) January 21, 2000. *www.escop.msstate.edu/committee/agbiotec.pdf*

Environment (p. 8)
Public discussions have raised a number of concerns about potential environmental effects of the use of crops derived from agricultural biotechnology. Among the most prominent are concerns

- that the flow of genetic material from genetically engineered crops to weed species will improve weed fitness.
- about the validity of industry claims that genetically engineered varieties can help improve environmental quality by reducing the use of chemical pesticides.
- that the development of resistance to introduced genetic material will undermine the efficacy of widely used pest control products; and
- that the use of marker genes will accelerate the spread of antibiotic resistance.

The Land-Grant University (LGU) system can help inform discussions of these issues through research and education. In particular, research is sorely needed on all these topics because the current information base is inadequate.

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Transgenic Crops
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Amy Smith, Production

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