

Opportunities and Problems in Agricultural Biotechnology*

—by Neil E. Harl**

The genetic modification of crops, principally corn, soybeans and canola, has proceeded with striking success as a new technology during the past five years. Grower adoptions of crops resistant to potent herbicides (the “Round-Up Ready” crops) and crops resistant to the European Corn Borer (the so-called Bt crops) have been very rapid. Moreover, the genetic modification of plants to produce pharmaceuticals (so-called “biopharming”) such as proteins designed as a vaccine for hepatitis B, are well within the realm of reality over the next decade. One industry observer believes that in 10 years as much as 10 percent of the acreage devoted to corn in the United States could well be used to produce pharmaceuticals. Some firms are betting that genetically modified plants could be used to produce substances that would reduce the cost of making chemicals used in plastics, detergents and construction materials.

The phenomenon of genetic modification is not limited to crops. Professor Patrick Bateson, of the Royal Society, the UK’s unofficial academy of sciences, and chair of the society’s working group on genetically modified animals, a few weeks ago highlighted a list of benefits that could become reality. Those benefits included cures for intractable diseases, relief from suffering for millions of patients, genetically modified hogs free of intestinal disease, genetically modified cattle immune to foot and mouth disease, and genetically modified chickens resistant to salmonella.

I. Resistance to Genetic Modification

Consumer resistance

Unlike other technologies, which were adopted in agriculture and in processing with relatively little consumer resistance, genetic modification of foods has encountered a stiff headwind in several countries, particularly in Europe and in Asia, and has led to consumer support for food labeling. Indeed, even in the United States polls have indicated that substantial numbers of consumers favor food product labeling to reveal use of genetically modified ingredients. In April of this year, the Pew Charitable Trust released the results of a poll conducted by the Trust which indicated that 75 percent of respondents in the United States indicated that they wanted to know if their food contained genetically modified ingredients. About 58 percent reportedly stated that they were opposed to the use of such ingredients in food. Other polls have indicated similar findings. An ABC News poll in mid-June indicated that 93 percent favored labeling; 52 percent believed that genetically modified foods were unsafe. Concerns in several other countries in Asia, Europe and the Southern Hemisphere have led to labeling or plans for labeling.

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Quite clearly, the trend has been toward more consumer resistance, not less.

Traditionally, consumers have been the major beneficiaries of technology in agriculture. Consumers may ultimately benefit from agricultural biotechnology if the technology leads to increased output and lower prices or to better nutritional qualities to the extent those developments would not have occurred otherwise and *to the extent the benefits are passed through to consumers*. Thus far, consumers in the U.S. have been largely unimpressed and many abroad, particularly in Europe and parts of Asia, have been somewhat antagonistic to genetically modified foods.

The reasons behind consumer resistance are not difficult to fathom. If consumers do not see a benefit to them, either in the form of lower priced food or in the form of food with superior qualities, any concern about food safety leads to consumer discounting of the value of foods with genetically modified ingredients and a preference for foods that have not been genetically modified.

Environmental concerns

Interest groups focusing on what they perceive as environmental concerns have identified several potential risks linked to genetically modified plants and animals. Concerns have been voiced over the spread of traits from genetically modified crops into other plant species, the emergence of resistance in plants to control measures, the production of superviruses and the inadvertent suppression of immune systems in animals which could have decidedly negative effects on animal populations. More fundamentally, some argue that the subtle and delicate relationship between the genetic material of living things and the ecosystems in which they inhabit could be upset with dramatic changes from genetic modification.

II. Consequences of Resistance

The concerns voiced by consumers and environmentalists predictably have led to quite different societal responses.

Environmental response

The articulated concerns over environmental or ecosystem threats have led principally to calls for more effective regulatory oversight. The Environmental Protection Agency, with lead responsibility for environmental matters, has ramped up its regulatory agenda to include studies of potential threats to the environment. A study by the National Academy of Sciences of animal cloning is due early next year. The Food and Drug Administration will use the results of the NAS study to decide whether cloned animals will require regulatory approval before sale of meat and milk from cloned animals. In the meantime, biotechnology companies involved in cloning have been asked to keep cloned livestock out of the food chain until the agency completes its review. Among the questions being pondered by FDA is whether cloned animals should be treated as genetically engineered animals, which are regulated, or like animals bred through in vitro fertilization which are normally not regulated. One scientific concern is whether mass animal cloning could lead to breeds that are more susceptible to disease.

Food safety concerns

Concerns about food safety have led to calls for more effective regulatory oversight and for labeling in order for consumers to know what they are consuming. While some doubt the value of labeling, it is likely that the move toward more labeling of foods containing genetically modified ingredients will continue with widespread, if not universal, labeling within three years.

One highly important feature of the debate is that the consumer is king. In the types of open, transparent, market-oriented economic systems which now dominate the world, the consumer, through the exercise of consumer choice, provides a continuing plebiscite over every feature of the food supply. The consumer may be right or wrong, informed or misguided, flippant or serious-minded. Nonetheless, it is consumer choice that drives the entire food system. If significant numbers of consumers register their preferences on a food feature or trait, and that preference is negative (or positive), the results are quickly transmitted through the food chain to the producer. For that reason, it is the consumer that sits in judgment over agricultural biotechnology along with the regulators. It is important to note that consumer choice can trump the regulatory process in that a product deemed safe and environmentally benign may, nonetheless, be rejected by consumers. At the same time, regulators can only trump consumer choice by limiting or banning products before entering the food chain.

In reality, however, the consumer is not always the moving force behind rejection or acceptance of foodstuffs. Processors look after the “king” and devote a great deal of time and resources to anticipating consumer response. No processor wants to be on the wrong side of consumer preference. For that reason, the more dramatic developments over the last two years over genetically modified foods have come from processors which ostensibly were anticipating consumer reaction. The Frito-Lay decision on genetically modified raw material for its chips; the decision by Novartis (through its babyfood subsidiary, Gerbers); the move by various brewers in Japan and in Mexico to reject genetically modified ingredients; the announcement by McDonalds to use non-genetically modified materials in its potatoes; and the announcement on June 20, 2001, that Calbee Food Co. had recalled its popular Jagariko line of snacks in Japan because of the discovery that the snacks were made from genetically modified potatoes; all were taken well in advance of the emergence of consumer pressure directed at the firms. As Carole Burke, editor of Japan’s Food Industry Bulletin has stated, “all leading food-processing companies in Japan are very conscious of consumers’ fears of GM foods. Market leaders in all segments of the food industry are demanding GM-free commodities, and the menus of major restaurant chains note their foods are GM-free.”

III. Impact on Trade

Predictably, resistance to genetic modification of foodstuffs has produced clear and unmistakable impacts on trade patterns. U.S. corn and soybean exports to the EU, and corn exports to Japan have been adversely affected by the inability to assure suppliers of non-genetically modified commodities.

Although there is evidence that Brazil’s exports are not completely free from genetic modification, Brazil has officially positioned itself as a reliable source of supply for non-genetically modified corn and soybeans. The country achieved that reputation principally by

banning the import of all genetically modified seeds and commodities. Brazil's status as a reliable source of non-genetically modified crops was a key factor in South Korea's recent decision to import Brazilian, rather than U.S., corn. In Asia, Thailand is particularly well positioned to serve the non-genetically modified market. More than two years ago, the Government of Thailand banned the import and cultivation of commercial seeds which had been genetically modified. While there are experimental field trials of genetically modified cotton in Thailand and the government-funded National Centre for Genetic Engineering and Biotechnology is conducting research into genetically modified tomatoes, cucumbers and papaya, there is concern that the field trials may not continue.

The May 28, 2001, edition of *Feedstuffs* reported that Australia's Industrial Suppliers Office had "identified the non-genetically modified (non-GM) status of Australia as a possible advantage over other soybean producers, such as the U.S., which has more than half its soybean crop sown to GM varieties." A May 21, 2001, news report stated that a delegation from India, sponsored by the Soybean Processor's Association of India, met trade officials in Italy, Spain, France, Germany, the Netherlands and Britain to attempt to persuade buyers that their soybean meal is non-genetically modified, unlike that of other export competitors. The report indicated that India was already exporting 2.5 to 3 million metric tons per year of non-genetically modified soybean products to Asia.

To the extent the market for non-genetically modified commodities is met without discount or premium, the situation does not pose a serious economic threat to exporters of genetically modified crops. However, a continued trend toward greater demand for non-genetically modified food ingredients could lead to serious problems for those countries dominated by the production of genetically modified commodities.

IV. The Future of Agricultural Biotechnology

The controversy over genetic modification of crops is expected to be resolved on the basis of three economic relationships—(1) the demand for GMO and non-GMO crops; (2) the supply of GMO and non-GMO crops; and (3) the costs for maintaining a two-track or multiple-track production, marketing and handling system and who bears those costs.

Demand for GMO and non-GMO crops

The demand for GMO and non-GMO crops promises to be highly important to the future of agricultural biotechnology. That factor is squarely in the hands of consumers, worldwide, and in the hands of processors which continually endeavor to anticipate consumer demand.

Arguably, the labeling of foodstuffs as to the GMO status of ingredients will make more precise the demands of consumers. As noted earlier, consumers will ultimately get what they want. On May 3, the U.S. Food and Drug Administration closed a comment period to ascertain if the public wants genetically food labeled as such.

Some see in the estimated 20 percent per year growth in the organic food market in recent years (estimated to total close to a \$10 billion market in a March, 2001, report by Solomon Smith Barney) evidence that, absent labeling, consumers will seek organically grown foods. Regulations under the National Organic Standard Program, authorized in the 1990 farm bill,

were recently finalized, reviewed by Congress and became law on April 21. The regulations, which become effective October 21, 2002, increase the minimum percentage of organic ingredients in products labeled “Made With Organic Ingredients” and impose limits on genetically modified foodstuffs in certified organic foods.

On April 5 of this year, the *Wall Street Journal* published a study of genetically modified foods. Twenty food products labeled as “non-GMO” or “GMO-free” were tested by a prominent food laboratory on behalf of the *Journal*. Of the 20, 16 contained evidence of genetic material used to modify plants. As the *Journal* article stated, “the problem, regulators say, is that some genetically modified crops—which have been designed to resist disease, pests and chemicals—can cross-pollinate freely with regular crops, passing along their altered traits to the next generation.”

Supply of GMO and non-GMO crops

The supply of GMO crops and non-GMO crops, the second critical economic variable in the future of agricultural biotechnology, is squarely in the hands of producers, worldwide, as producers make decisions about seed selection each year.

Notwithstanding the rapid adoption of corn resistant to the European Corn Borer and crops resistant to potent herbicides, the evidence is clear that, in the long-run, producers rarely benefit from new technologies and often suffer economically from their adoption.

As has been known for several decades, only early adopters benefit economically from output increasing technology—such as fertilizers, chemicals and better seed, such as Bt corn. That’s the type of corn that creates a substance toxic to the European Corn Borer so the technology increases yields.

Why do farmers not benefit from output increasing technology? With inelastic demand for most agricultural products, increases in output in the aggregate reward producers with a disproportionate drop in price and in profitability. That’s been known and documented for decades. Farmers have been on a treadmill. They have to adopt technology to be competitive but they are rewarded by lower prices and profits if they do.

Even cost decreasing technologies, such as Roundup Ready Soybeans, are ultimately output increasing as such technology enables crops to be grown in areas where production would be uneconomic were costs higher. Thus, cost decreasing technology, also, ultimately leads to an increase in output which means a disproportionate drop in price and in profitability for the producer.

In recent years, the pace of adoption of new technology has been so swift both here and abroad as to leave little benefit for producers, even for early adopters.

The stream of output increasing and cost-decreasing technology has been a major reason why producers, particularly crop farmers, have been under economic pressure much of the time over the past 70 years.

The cost of maintaining segregated crop supplies

A major problem faced by the U.S. and other producers of genetically modified crops on a widespread basis is the feasibility and cost of a two track or multi-track marketing and handling system. For crops that are particularly susceptible to gene flow (such as corn because of pollen drift), the tolerance level (amount of GMO germ plasm in non-GMO crops) is critically important. Contamination can occur from several sources—(1) contamination of GMO germ plasm in non-GMO seed coming from the seed companies; (2) pollen drift in the field; (3) physical contamination in planter boxes, combines, augers, elevators, wagons and bins on the farm; and (4) physical contamination at the elevator or other handler of the commodity after it leaves the farm. Research indicates that the cost of segregation rises exponentially as the tolerance level is reduced.

The experience with StarLink™ corn in 2000 illustrates how widely unacceptable supplies of crops can become diffused throughout the food system. In that case, StarLink™ was approved for feed use but not for food use by the Environmental Protection Agency. As the terms of the registration stated, “none of the seeds, plants or plant materials in the StarLink™ plot, or within 660 feet of the field, may be used for food uses or may enter international commerce.” EPA was concerned that the CRY9C protein in StarLink™ possessed qualities that could cause allergic reactions in humans (although the Centers for Disease Control and Prevention, in mid-June 2001, announced that it was unable to conclude that reported illnesses were the result of the StarLink™ corn). After traces of the protein were found in various food products, starting with taco shells, an effort was made to locate and dispose of supplies of the StarLink™ corn from the 2000 (and earlier) crops.

Unfortunately, not all producers acquiring StarLink™ seed were advised of the limitation on use and disposition of the crop. The 11 licensees of the seed from Aventis Crop Science were the actual sellers of the StarLink™ seed and apparently, in some instances, did not advise producers of the limited registration and the possible consequences if other corn was contaminated with the StarLink™ germ plasm. Therefore, contamination occurred inadvertently at planting and harvest, pollen drift produced gene flow into non-StarLink™ fields and the StarLink™ crop was commingled with other corn in on-farm storage and at elevators. While the number of acres planted to StarLink™ totaled only 340,908, the number of bushels containing the StarLink™ protein was several times the production from those acres actually planted with StarLink™ seed.

EPA cancelled the registration on October 12, 2000. Aventis Crop Science moved quickly to isolate the corn containing StarLink™ and offered producers 25 cents per bushel premium over the October 2, 2000, market price for corn; agreed to compensate growers producing corn within 660 feet of StarLink™ corn with the same price premium; assured elevators that the company would pay elevators for “additional transportation, demurrage and testing costs incurred by a grain elevator because of commingled corn;” and agreed to “work with” elevators to address problems related to discounts in value of StarLink™ contaminated corn.

Even with the aggressive efforts by Aventis Crop Science, augmented by pressure from state Attorneys General in several states, but particularly in Iowa and Missouri, the StarLink™ crop promises to continue to flow through the food chain for several months. The recent announcement by the Centers for Disease Control that StarLink™ was not the cause of allergic reactions may allay some of the concerns.

In late winter, 2000-2001, the U.S. Department of Agriculture asked 280 seed companies to test their seed supplies for traces of the StarLink™ protein and offered to purchase the seed supplies failing the test. Some lots were found to contain StarLink™ and USDA reportedly set aside \$20 million to purchase that seed. However, about one-fourth of the seed companies did not respond. The possibility is that part of the 2001 corn crop was planted with seed containing StarLink™ germ plasm.

This highlights a shortcoming of the oversight process over foodstuffs in the United States. The federal government lacks recall authority, on mandatory basis, over commodities or other food ingredients. This lack of authority is especially notable if—(1) the crop is visually indistinguishable (which it was) and (2) there is a perception of value on the part of the producer.

The StarLink™ controversy focused attention on civil liability in such situations.

- A commercializing company or licensee that fails adequately to warn producers of limits on the production or marketing of the resulting crop could be liable to growers who suffer damages. Licensing agreements would presumably address problems of liability in this area.
- A producer who knowingly ignores limits on registration could be liable for damages suffered by owners of neighboring fields to which pollen drifts (for those crops susceptible to pollen drift).
- A producer who delivers a crop contaminated with unacceptable germ plasm could be liable to the elevator for damages suffered. Farmers who are deemed to be “merchants” under the Uniform Commercial Code are subject to—(1) express warranties made orally or in writing about the crop; (2) implied warranties of merchantability about the crop passing without objection in the trade; and (3) implied warranties of fitness that the crop is fit for the purpose for which it is to be used, if known to the seller.
- Firms processing, manufacturing and distributing food products could complain of damages to those who sold them ingredients unsuitable for use, presumably elevators and grain handlers and shippers. Claims could include actual damages from product recalls, increased handling and manufacturing costs and damages to brand identities and reputations.
- Consumers who suffer damages could have a claim against food suppliers and manufacturers if damages can be proved.
- Finally, producers may have a claim, against the commercializing company or companies, if it can be proved that the offensive germ plasm resulted in a discount for the crop generally in the country. Several class action lawsuits have been filed in the United States alleging that

corn producers in general were damaged by the StarLink™ episode even though there was no contamination of their crop by the CRY9C protein.

Possible outcomes

The development and production of transgenic crops is known to be a costly process. The process can only be supported, economically, if there is a robust revenue stream from sales of resulting products.

If consumer resistance stabilizes or wanes, the three economic relationships are likely to produce—(1) niche markets for non-GMO crops, in part on a country-by-country basis where gene flow from pollen drift and from mechanical contamination can be rather easily controlled; (2) a modest premium for non-GMO crops (sufficient to produce the supply to serve that market); and (3) disputes over trade rules imposed by countries which restrict GMO seed and commodities as to whether such rules constitute barriers to trade.

In the event consumer resistance increases, the countries with high rates of GMO plantings will be confronted with the choice of—(1) relinquishing the non-GMO market to other countries; (2) gearing up for simultaneous production of GMO and non-GMO crops (and maintaining acceptable levels of segregation of the crops; or (3) reducing GMO plantings. The outcome is almost certainly to be resolved on an economic basis, in light of the three basic economic relationships outlined earlier. Any one of the three outcomes is likely to produce a reduced revenue flow to the commercializing companies.

V. Solutions for Countries With Multi-Track Aspirations

With the odds currently favoring increasing consumer resistance, exporting countries with substantial plantings of GMO crops and a reputation as a GMO supplier are expected to gear up for simultaneous production of GMO and non-GMO crops with intensive effort devoted to (1) maintaining acceptable levels of segregation of the crops and (2) developing a reputation, worldwide, as a dependable supplier of both GMO and non-GMO crops. For countries nudged in that direction, several steps can be taken to facilitate the task.

- One superficially attractive solution is to zone a country for crops on the basis of genetic modification. This is expected to be unworkable for several reasons. No area within a country wants to be on the losing side of an evolving market. Moreover, such a move is antithetical to the time-honored tradition of producers being given free rein to produce what they want.

What could emerge, is a form of de facto zoning as producers, on a local basis, voluntarily agree to limit their plantings to non-GMO crops in order to be positioned to take advantage of non-GMO markets. This would require buffer areas unless natural barriers (such as rivers or mountains) limit sufficiently gene flow from pollen drift for crops for which that can be a problem.

- Another step that could be taken is for the regulating agencies to require the ultimate purchasers of seed that has not been approved for all uses and approved for export as well as

domestic use, to advise in writing well in advance of planting all producers within at least one mile from every field planted to the limited registration crop. The requirement should also require the grower planting the limited registration crop to obtain the approval of all other growers within the one mile radius to signify approval of the planting of the limited registration crop which could involve negotiated payments.

- A multi-track system of crop production, involving both GMO and non-GMO varieties, will likely produce acceptable results only if there is low cost, quick and reliable testing of the presence of GMO germ plasm at every point of commingling of the crop. This is clearly not possible at present and is likely to be unattainable in the near term although the development and implementation of testing protocols would be accelerated in the face of economic pressure brought on by loss of markets for crops.

- As an interim measure, a certification procedure, of the type developed in the autumn of 1999 by Iowa State University and the Office of the Iowa Attorney General would provide a helpful paper trail albeit with some shortcomings. The Iowa “Uniform Certification Procedure,” involves a pre-delivery certification segment which requires a declaration of the particular varieties planted, where they were planted and the seed lot (for tracing any gene flow problems in the production of the seed); that reasonable care was utilized in planting, harvesting, handling and storage of the crop; and a disclaimer of implied warranties of merchantability and fitness. The post-delivery portion is completed upon delivery and associates the scale tickets (and any sample identification for samples obtained for later testing) with the pre-delivery portion of the certification. The obvious shortcomings are—(1) a stack of certifications does not assure that the crop is uncontaminated (particularly in light of misrepresentations in a market environment of significant premiums for non-GMO crops); and (2) once samples are tested, the load has already been dumped into a bin based on the representations made with the potential for large-scale contamination.

VI. Conclusions

Clearly, every group involved significantly in the process of production, handling, processing and distribution of foodstuffs as well as the regulatory agencies with oversight responsibility needs to be fully aware of the highly dynamic nature of the problems posed by the introduction of genetically modified hybrids. The problems of being able to mask the identities of some genetic features to avoid detection in testing adds to the concern and complicates the public policy response.

Moreover, every group with an interest in the operation of the food system should be aware that the outcome ultimately depends upon the three basic economic relationships outlined above.

Obviously, the prudent course would be to adopt some contingency plans with an eye to a less-than-best case scenario, at least in countries with heavy plantings of GMO crops.

APPENDICES

Proposed Uniform Certification Form (pre-delivery and post-delivery)

Proposed Purchaser Certification Form



PROPOSED UNIFORM CERTIFICATION (PRE-DELIVERY PORTION OF CERTIFICATION)

I, _____, residing at _____
(Name of Producer) (Address)

_____, have delivered _____ in the amount of _____ bushels.
(corn or soybeans)

The delivery(ies) are represented by scale ticket numbers and sample numbers which will be specifically identified after delivery is completed in the "Post-Delivery" portion of this Certification.

With regard to the above-referenced grain, by placing my initials in the corresponding blank, I hereby certify and affirm the following:

1. The above-referenced grain was grown from the following varieties of seed:

	<u>Seed company</u>	<u>Variety No.</u>	<u>Lot</u>	<u>Where produced*</u>
a. _____	_____	_____	_____	_____
b. _____	_____	_____	_____	_____
c. _____	_____	_____	_____	_____
d. _____	_____	_____	_____	_____
e. _____	_____	_____	_____	_____;

_____ 2. I used ordinary care to clean my harvesting equipment prior to harvesting the above-referenced grain;

_____ 3. I used ordinary care to clean my on-farm storage facilities prior to placing the above-referenced grain in said facilities;

_____ 4. I used ordinary care to clean the transportation delivery vehicles prior to using said vehicles to deliver the above-referenced grain; and

_____ 5. (Other) _____

No other warranties, express or implied, including implied warranties of fitness and implied warranties of merchantability, are made as to the commodity in question with respect to the commodity's nature, genetic composition, fitness for a particular purpose or use or otherwise.

Name

Date

Address

Telephone No.

* Legal description or informal field designation

Source: Office of the Iowa Attorney General and Iowa State University.



(POST DELIVERY PORTION OF CERTIFICATION)

The delivery(ies) made pursuant to this Certification are evidenced by scale ticket number(s)

_____, and sample number(s) _____.

Name

Date

Address

Telephone No.



PROPOSED PURCHASER CERTIFICATION STATEMENT

I hereby certify and affirm that the lot of _____ which is the subject
(corn, soybeans)
of this statement, described as containing approximately _____ bushels and sold this
_____ day of _____, 1999, was harvested from seed represented by the seed
supplier as non-genetically modified, and that the commodity in question was not the product of
seed represented by the seed supplier as genetically modified. The undersigned has on file
certifications of producers indicating the variety planted in each case and certifying that
ordinary care was used in harvesting, handling, drying and storing the commodity in question to
avoid contamination with genetically modified varieties. The undersigned further certifies that
reasonable care was used in receiving, handling, storing and shipping the commodity in question.

**No other warranties, express or implied, including implied warranties of fitness and
implied warranties of merchantability, are made as to the commodity in question with
respect to the commodity's nature, genetic composition, fitness for a particular purpose or
use or otherwise.**

Purchaser

Address

Date