Plant Biotechnology: A Progress Report and A Look Ahead

Approaching the second successful harvest of commodity crops improved through biotechnology, agricultural companies continue to work closely with the feed and food industries toward a new generation of products. In 1996, Feedstuffs published the first in what has developed as a series of articles about plant biotechnology and its resulting feed and food products. The March 4, 1996, article, "Added-value grains to have expanded value in feed," discussed the vast opportunities genetically-engineered plants offer, as well as the challenge of harnessing the value of these plants within the infrastructure of the animal feed industry. The May 20, 1996, article "Plant biotechnology and the feed industry," continued this discussion, highlighting genetically-engineered feed products close to commercialization and the regulatory oversight involved in the process. Finally, the Oct. 28, 1996, article "Glyphosate-tolerant soybeans found safe for use in feed," focused on one specific product and summarized the safety assessment of this new plant. Now that a number of genetically-modified plants are commercialized, how have growers, feed and food processors, and consumers accepted the first products of biotechnology? And, as more crops move toward commercialization, what benefits can we expect?

By Dr. Molly N. Cline and Diane B. Re

In 1996, the first commodity crop seeds improved through biotechnology -- including soybeans, corn, cotton and canola offering built-in herbicide tolerance and insect protection -- became commercially available to growers. Food and feed processors began to incorporate the resulting crops into finished products for the first time, writing a new chapter in the history of agriculture and food production.

In 1997, the number of acres planted with crops developed through biotechnology increased six-fold and more growers around the world are joining North American growers as they reap the benefits of these exciting new developments.

Commercialization of plants developed through biotechnology always follows many years of extensive discovery, research, testing and regulatory review. The first

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crops offer primarily agronomic improvements benefitting growers, and these will soon be followed by quality improvements benefitting the feed and food industries. A broad view of the industry's successes is important to understanding products that contribute to the feed industry. Each product of biotechnology builds on the products developed before. For example, when Calgene introduced Flavr-Savr tomatoes in 1994, no one could anticipate some of the products discussed in this article. Yet, the technology of one genetically engineered product brings key learnings and more rapid development with successive products.

This discussion will provide an update on some of the crops harvested in 1996 and crops planted this year, as well as a brief overview of what agricultural experts see for the future. Using Monsanto as a barometer of industry performance, we'll focus on three of the company's crops planted over 1996 and 1997. As we look to the future, we'll discuss more broadly a variety of crops under development by a number of industry leaders. In closing, we'll discuss regulatory, industry and consumer acceptance.

1996 Commercial Crops: Satisfied Growers

In 1996, growers commercially planted Monsanto's herbicide-tolerant soybeans and canola for the first time. These modified crops allowed growers to apply Roundup herbicide over the top to achieve better weed control, enhance crop safety and choose the most appropriate tillage methods, including conservation tillage (direct seed), to help prevent soil erosion.

Growers also planted three insect-protected crops -- corn, cotton and potatoes -- which offer built-in protection from potentially devastating insect pests, helping reduce the non-sustainable inputs necessary to produce crops.

Last year, growers in the United States and around the world planted five million acres of crops improved through biotechnology. For example, more than 10,000 U.S. growers planted approximately one million acres of herbicide-tolerant soybeans (nearly 2 percent of U.S. soybean acreage) in 1996. Three seed companies sold all of the available herbicide-tolerant seed. In Argentina, growers planted roughly 250,000 acres of herbicide-tolerant soybeans in 1996, representing approximately 2 percent of the country's soybean crop.

Agricultural companies continued to monitor the crops closely. Results of

independent surveys they commissioned indicate growers saw good economic returns on their investment in these new crops and were satisfied with first-year results. Monsanto Company carefully followed the performance of its new crops:

Herbicide-Tolerant (Roundup Ready) Soybeans: A survey of more than 1,000 U.S. growers found Roundup Ready soybeans met or exceeded the expectations of 90 percent of growers. Almost half surveyed said their expectations were exceeded. In addition, four out of five said Roundup Ready soybeans represented a good (49 percent of respondents) or very good (30 percent of respondents) value, and 88 percent said they were likely to plant Roundup Ready soybeans again in 1997. In fact, 90 percent of 1996 growers actually did plant the improved soybeans this spring.

Research over several years has shown the Roundup Ready gene has no effect on the yield of soybean varieties, but improved weed control and enhanced crop safety can affect yield. Because of exceptional weed control and crop safety in U.S. Midwest yield trials, yields increased by approximately 5 percent, or two bushels per acre, when Roundup Ready soybeans were treated with Roundup Ultra instead of conventional herbicide programs.

Herbicide-Tolerant (Roundup Ready) Canola: In a survey of more than half of 1996 Roundup Ready canola growers, 94 percent judged control of annual weeds as excellent or good. Eighty-eight percent rated control of perennial weeds as excellent or good. Again, better weed control offered by Roundup Ready crops can result in increased yields.

Yield comparisons conducted in 1996 found that yields of Roundup Ready canola were more than 9 percent greater (nearly three more bushels per acre) than in fields treated with other weed control methods. Crop quality improved because fewer weed seeds were mixed into the harvested crop. Roundup Ready canola growers realized an average incremental return of almost $20 (U.S.) per acre after yield, seed and herbicide costs were taken into account.

1996 Commercial Crops: Environmental Benefits

For the grower, the new chapter in agricultural history was a story of success. But, the crops not only improved the economics of growers' operations, they also helped growers better manage their environmental resources. Monsanto crops' environmental

performance demonstrates the leadership role biotechnology can play in implementing sustainable agricultural practices.

In soybean and canola crops, for instance, growers traditionally have applied residual herbicides that stayed in the soil before and after the crops emerged. Roundup Ready technology allows growers to replace these residual herbicides with Roundup Ultra, a herbicide well known for its favorable environmental characteristics: it breaks down over time in soil, does not move to groundwater and does not accumulate in the environment or in the food chain.

Although the environmental profile of the herbicide used is more important than the total amount of herbicides applied, many people ask how this technology has affected herbicide use. In 1996, Roundup Ready soybean growers reported reductions in herbicide use from 9 percent in the U.S. East Central region to 39 percent in the U.S. Southeast, with variations due to regional climate differences, row spacing, and the kind and amount of weed pressure.

Approximately three out of four U.S. Roundup Ready soybean growers applied Roundup only once for weed control. Twenty-four percent made two applications and 2 percent applied the herbicide three or more times. Eighty percent of Canadian Roundup Ready canola growers used only one application of Roundup.

In addition, Roundup Ready crops offer other environmental advantages. The ability to use Roundup during the growing season is compatible with all tillage methods, including conservation tillage methods that help prevent soil erosion. Roundup effectively addresses the problem of weed pressure, a factor that can discourage growers from adopting conservation tillage methods.

1997 Commercialization in the U.S. and Beyond

The momentum created from the resounding success of the 1996 crops has continued into the 1997 growing season. More crops are on the market and larger amounts of seed were available this spring, allowing growers to increase the number of acres planted with improved crops. Also increasing are the regulatory approvals around the world.

Some of Monsanto's crops demonstrate the growth of this industry:

Soybeans: More than 85 seed companies offered several varieties of Roundup

Ready soybeans to growers in 1997; as in 1996, grower demand exceeded seed availability. Total acreage planted in the United States was nine million acres, 15 percent of total U.S. soybean acres. This past spring, Argentina completed its first commercial harvest of 250,000 acres, and growers in Canada had their first opportunity to plant Roundup Ready soybeans, planting 3,000 acres.

Canola: Seed companies offered Canadian growers greater quantities of Roundup Ready canola seed in more varieties in 1997, but seed availability still was limited. Canadian growers planted 500,000 acres. Roundup Ready oilseed rape, the winter version of canola, is currently under review in the European regulatory review process.

Corn: YieldGard corn, which offers built-in protection from the European corn borer throughout the plant throughout the season, received final U.S. regulatory approval at the end of 1996. Leading seed companies with licensing agreements for YieldGard include Pioneer, DeKalb, Golden Harvest and Cargill. In addition, Northrup King completed a separate U.S. regulatory review for its YieldGard corn in August 1996. U.S. growers planted 3 million acres with YieldGard corn in 1997; Canadian growers planted 10,000 acres. Regulatory reviews of YieldGard in other parts of the world, such as in Japan, are complete, and in Europe, are underway.

For its crops, Monsanto Company forecasts that total acres planted worldwide in 1997 will be between 18.4 and 20.7 million acres, up from 3.1 million in 1996.

The industry anticipates finding the same kind of performance results from this year's crops as last year's crops demonstrated. In July, growers were reporting outstanding results. Roundup Ready soybean growers, for instance, are saying they're impressed by the weed control, crop safety and the early plant growth they have experienced.

As we move to 1998 and beyond, agricultural leaders predict that growers worldwide will continue to plant an increasing amount of acreage of crops improved through biotechnology.

Products of the Future

As the agricultural industry embraces these improved crops, Monsanto and other companies are looking to the future, building on current products and looking at new

ways to use biotechnology to bring value-added products to the food and feed industries. These promising products will offer a wide variety of benefits, including new agronomic advantages for growers and nutritional improvements for the feed and food industries and consumers. Several products will offer multiple benefits through gene stacking -- the technique of introducing several beneficial traits into a single plant organism.

The list of possible products is long and diverse; below are a few of the most promising. As with any biotechnology products, commercialization will depend on successfully completing research, field trials and obtaining appropriate regulatory approvals.

Agronomic Improvements for Growers: Growers can anticipate that several products, scheduled to reach the market over the next few years, will improve their operational efficiency, economics and crop quality.

For example, corn growers planting Roundup Ready corn will be able to apply Roundup Ultra over the top of the crop to control more than 100 grasses, broadleaf weeds and vines, providing corn growers with a new level of weed control and crop safety. Roundup Ready corn is under development and seed is expected to be available for planting as early as 1998 or 1999. Of course, timing depends on product development, regulatory reviews and seed production. Using gene stacking, researchers also are developing a corn product that combines the insect-protection of the YieldGard product with the weed control of Roundup Ready corn.

Quality Traits for Nutrition Improvements for the Feed Industry: Although a majority of the first agricultural products developed through biotechnology benefit growers, the technology also holds potential for the feed industry. Researchers are looking at how to improve the nutritional quality of the grains used in feed and are developing plants to serve as factories for feed additives.

For example, both Monsanto and DuPont are developing high-lysine soybeans, which could be an alternative to synthetic lysine added to swine and poultry rations. This could lower production costs for the feed producers, and, ultimately, reduce the cost for customers. Researchers with a number of companies also are looking at how to develop a commercially viable high-lysine corn and high-methionine soy and corn. Because methionine, like lysine, is an essential limiting amino acid often added to most rations in a synthetic form, the high-methionine products will provide an alternative way to meet the

need for methionine. These improved feed grains are expected to be available around the end of the decade.

Other value-added products involve reducing or eliminating antinutritional factors in seeds, such as trypsin inhibitors, lipoxygenase, lectins and indigestible oligosaccharides. Producers can expect to see some of these products on the market in the next one to five years.

Quality Improvements for the Food Industry: Many biotech products will offer nutritional and functional benefits to food processors and their consumers.

Already on the market, Calgene's laurate canola, Laurical, and DuPont's Optimum High-Oleic soybeans offer processors different choices for oil ingredients. Laurate canola is a specialty vegetable oil containing high levels of lauric acid esters. It was developed in response to industry's desire for an alternative to imported sources of lauric oils but has been found to provide additional functional benefits in a variety of food systems. It can be used in confectionary coatings, coffee whiteners, icings and frostings and whipped toppings.

High-oleic soybeans contain less saturated fat than regular soybean oil. They consistently produce oil with an oleic acid content of 80 percent or more, compared with 24 percent from commodity soybean oil, while providing the added advantage of heat stability. Applications could range from spray oils for crackers to liquids for deep frying.

Products in the pipeline include improved high-stearate canola and soybeans, which produce improved oils for applications in margarine and shortening ingredients. High stearate oil is an ingredient in margarine and shortening that would require no hydrogenation and offer greater functionality and shelf stability than current products. Canola plants with more than 26 percent stearate in the oil have been produced and are in field trials.

Canola with increased medium chain fatty acids, also in the product pipeline, offers benefits to the medical and sport nutrition markets. Nutritional formulas made with the improved canola can be designed to accommodate medical patients on special diets or with particular digestive needs. It also offers a source of low calorie, quick energy to the sport drink market. Rapeseed plants with up to 38 percent medium chain fatty acids have been produced in the greenhouse.

Quality Improvements for Consumers: Consumer acceptance of these

products are the ultimate measure of their success. Many of the products coming for the food and feed industry could ultimately benefit consumers. As members of the food and feed industries, we must continue to ensure that consumers understand the benefits biotechnology brings to all levels of the value chain -- from growers to processors and, finally, consumers. Several products in the pipeline offer direct benefits to consumers and should help illustrate the promise of biotechnology.

One of the most exciting examples is Monsanto's higher-solids (starch) potato. For French fry lovers who want to reduce the fat, higher-solids potatoes will contain less moisture. With the reduction in the percentage of water in the genetically improved potato, less oil is absorbed during processing, resulting in a reduction of cooking time and costs, better-tasting French fries and an economic benefit to the processor. These potatoes could be commercialized as early as 2002.

Regulatory and Technology Acceptance

As biotechnology evolves and more products enter the marketplace, companies will continue working with regulatory authorities around the world, as well as ensuring that the users of the products -- food and feed processors and consumers -- are accepting of them.

For years, companies introducing plant biotechnology products with agronomic benefits have cooperated with regulatory agencies in the United States and around the world to demonstrate that new crops are equivalent to crops currently on the market. In addition to demonstrating substantial equivalence, this process ensures the public that products developed through biotechnology are environmentally sound and safe to use and consume.

In 1996 and 1997, the first biotechnology crops -- including soybeans, corn, canola, cotton and potatoes -- were harvested, commingled with traditional crops and handled like any other commodity crop. Many food and feed processors began processing these crops successfully into food products and animal feed ingredients.

With the advancement of value-added products, companies will continue to work with regulatory agencies to ensure substantial differences are noted appropriately on labels.

Agricultural companies also will continue to communicate diligently, with

regulators and with a wide range of people connected to the food and feed industry, about the new crops and their benefits. Through personal contacts, speeches, publications, representation at trade shows and in industry publications, we must keep a wide variety of business leaders, scientists, trade organizations, professional groups, company leaders and consumers worldwide up to date.

Clear, regular communications will ensure a strong marketplace, over the long-term, for the products of biotechnology and the many exciting benefits they promise. To date, research shows the new products have not been an issue in most areas. However, communications programs in place around the world will ensure that accurate information is readily available to anyone who wants it.

Industry Education: In addition to agricultural company communication efforts, industry groups have taken a leadership role in ensuring industry acceptance.

In particular, the American Feed Industry Association (AFIA), the only national association that exclusively represents the interests of the U.S. feed and pet food industries, works with Congress and federal and state regulatory agencies to build upon the already excellent quality and safety record of the U.S. animal feed industry.

AFIA closely monitors and acts upon state and federal legislative and regulatory actions related to feed and pet food issues. It directly addresses issues that impact its membership and have the potential to shape its future, including biotechnology. In its Issue Summary on Biotechnology, AFIA states its position, "AFIA supports biotechnology that will benefit the industry, our customers and U.S. consumers. We oppose unreasonable or ill-advised regulation based upon emotion or perception.

"AFIA also strongly supports biotech industry outreach and education efforts. Feed industry and pet food companies, the farmer/rancher/pet owner customers for those companies, and ultimately the average consumer, AFIA says, must understand at least the basics of the science underlying biotechnology. It's only in this way they can be confident in the safety and the quality of the products biotechnology will bring to them."

In 1994, AFIA led a coalition of national animal producer groups that worked to defeat bills that would have regulated the agricultural biotechnology industry in what the association viewed as an unnecessary manner. In 1996, AFIA joined with others in the agriculture sector to establish Ag for Biotech, a coalition of industries that directly benefit from the advances of agricultural biotechnology, and which work together to influence

both domestic and overseas policy initiatives aimed at restricting the applications of biotechnology in the food and feed industries.

AFIA also works with the Association of American Feed Control Officials (AAFCO) to ensure ingredients of products to be used as animal feed and pet foods are safe by meeting regularly to discuss industry issues. Comprised of regional, state and federal agency officials who regulate production, analysis, labeling, distribution and sale of animal feeds and livestock remedies, AAFCO works to promote uniformity in laws, regulations and enforcement policies among other policy objectives.

Consumer Education: Several organizations work closely with opinion leaders to educate consumers and monitor consumer acceptance of biotechnology.

The International Food Information Council (IFIC), for example, a non-profit organization, serves as an information and educational resource on nutrition and food safety. IFIC provides science-based information to journalists, health professionals, government officials and other opinion leaders who communicate with the public.

IFIC has worked to inform these audiences about biotechnology and its effects on food. IFIC explains, "Any emerging technology, if isolated and considered out of context, will tend to confuse and overwhelm people. Only when new products are described in real terms and compared with familiar products can consumers appreciate the new product benefits and the choices they offer."

To provide audiences with the most appropriate information, IFIC monitors trends in consumer opinion. For example, a March 1997 IFIC survey of more than 1,000 U.S. consumers found that nearly eight of ten (79 percent) consumers are aware of biotechnology and (78 percent) expect to derive benefits from the science within the next five years. In addition, the study indicated nearly eight of ten (78%) consumers support the United States Food and Drug Administration's current labeling policy, which requires foods modified through biotechnology to be labeled as such only when biotechnology's use introduces a new allergen or substantially changes the food's nutritional content.

IFIC will continue to coordinate with key audiences to disseminate science-based information about biotechnology and help consumers make educated purchasing decisions.

Conclusion

All of these efforts will help ensure acceptance of current products and lay the groundwork for improvements in other foods that will offer additional benefits to growers, feed and food processors, and consumers. As the biotechnology industry moves more products closer to commercialization, researchers are looking at even more possibilities for plant improvements. The complete list of all the possible products lies in the minds of the researchers. Through collaboration with the food and feed industries, these possibilities will evolve into more exciting products, just as collaboration with growers has resulted in many exciting products benefitting their business.

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