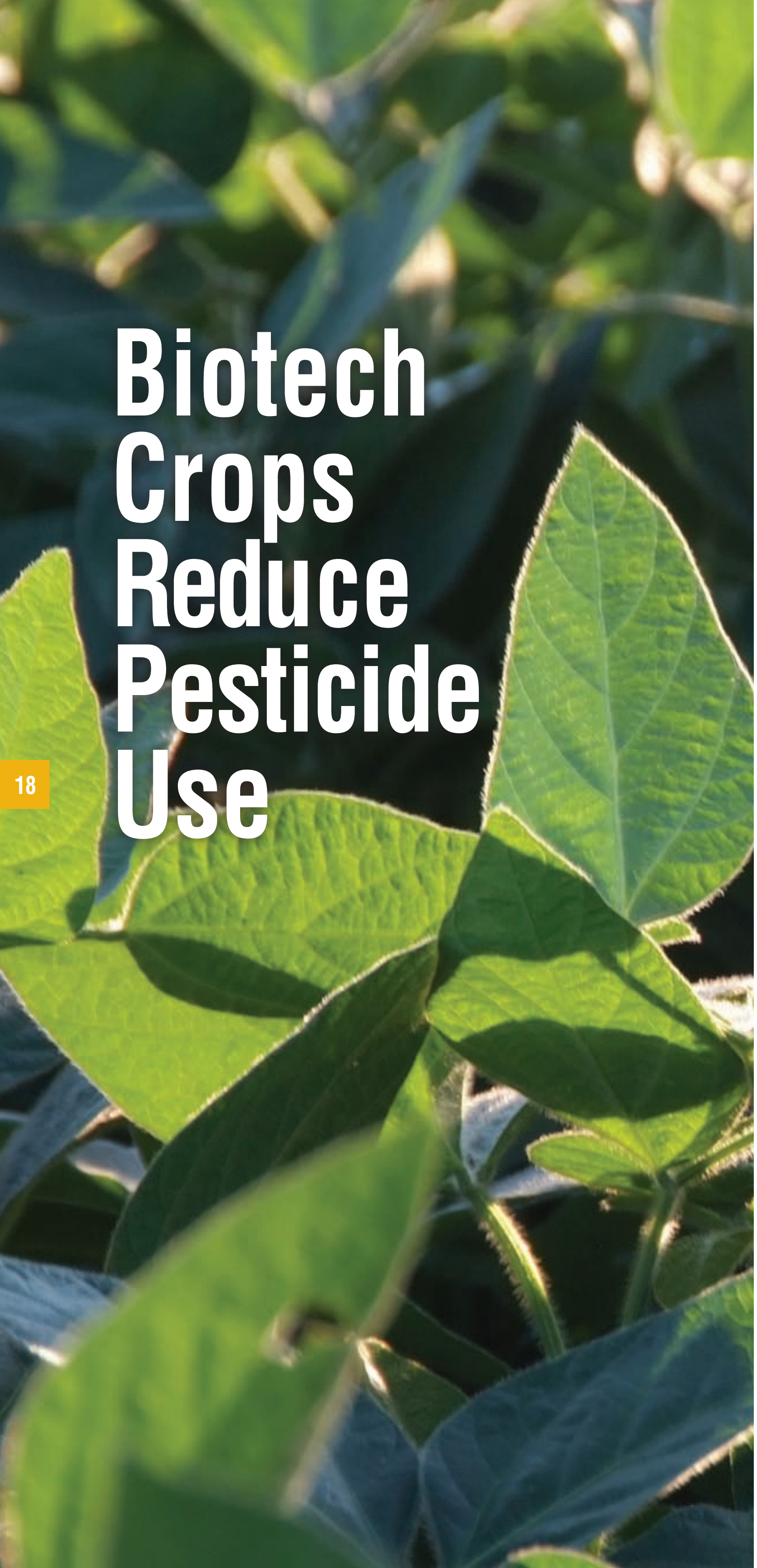


Biotech Crops Reduce Pesticide Use

Among the most attractive benefits of many early biotech crops – from a grower perspective as well as an environmental one – is their built-in ability to combat pests such as insects or pathogens, or to allow producers to use highly effective products to fight weeds. The net result is not just more grower-friendly crops, but also a reduction in the cost of production and the use of crop protection chemicals.

Combating Weeds

Weeds are the leading challenge for soybean growers worldwide, causing more yield loss than either insects or diseases (Heatherly et al., 2009; Oerke, 2006). Oerke (2006) estimates global yield loss to weeds at 37 percent. The development of herbicides in the latter half of the 20th century replaced time- and tillage-intensive mechanical weed control with management-intensive chemical control.

Herbicides brought challenges of their own. The efficacy of available herbicides on specific weed species caused shifts in the population dynamics of weeds, with less-adequately-controlled species increasing in dominance until other herbicides or mechanical weed control were introduced. Many persistent soil herbicides, used for decades on millions of acres of cropland each year, found their way into streams and groundwater.

Targeting, timing and application also require knowledge and skill. By 1996, the year glyphosate-tolerant soybeans were introduced to the marketplace, 27 different herbicidal active ingredients representing nine distinct modes of action, each with its own strengths and weaknesses, were registered for use in U.S. soybeans (Heatherly et al., 2009). By contrast, planting Roundup Ready soybeans allowed growers to apply glyphosate, the active ingredient in Roundup and several other herbicides, as a broadcast post-emergence spray to control a broad spectrum of weeds in one or two applications.

Glyphosate is a remarkable herbicide, both in its efficacy and its environmental profile. When it comes in contact with plant tissue, glyphosate translocates quickly through the plant to accumulate in the growing point. There, it inhibits the action of the 5-enolpuruvylshikimate-3-phosphate synthase (EPSPS) enzyme, which plays a vital role in the growth of plants, fungi and bacteria. Inhibited by glyphosate, the EPSPS system fails and the plants die – even perennial weeds that were extremely difficult to control with other herbicides. In fact, glyphosate is labeled for control or suppression of well over 100 weed species (Monsanto, 2007).

Ordinarily, glyphosate would also kill the crop. However, there are two EPSPS enzyme systems in nature – EPSPS 1, found in plants, fungi and some bacteria, which is susceptible to glyphosate, and EPSPS 2, a version found in some bacteria that is not inhibited by glyphosate (Shaner, 2006). To create glyphosate-tolerant soybeans, breeders used genetic transformation technology to move a gene for the EPSPS 2 system from a soil bacterium to a soybean plant. The transformed soybean line was then crossed with elite germplasm to create high-performing soybean varieties that rely on the EPSPS 2 enzyme system rather than the glyphosate-susceptible EPSPS 1 pathway.

Better Environmental Profile

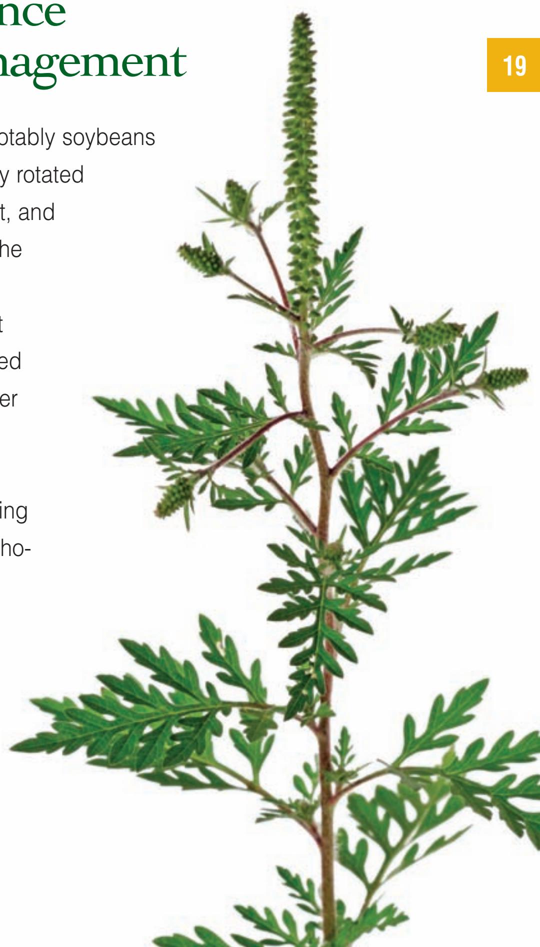
According to the Extension Toxicology Network (Extoxnet, 1996), a multi-university clearinghouse for information on crop protection products, glyphosate is "practically non-toxic by ingestion," "practically non-toxic to fish," and long-term feeding studies have consistently shown no adverse effects even after two years of high-rate exposure in the diets of several animal species. The molecule is also tightly bound to soil particles almost immediately, which renders glyphosate unlikely to leach into the soil or run off in the event of rain (Extoxnet, 1996). Glyphosate also has a half-life in the environment of 47 days, compared with half-lives of 60 to 90 days for the herbicides it replaces (Heimlich et al., 2000).

Using the U.S. EPA's reference dose for humans to create a chronic risk indicator, USDA calculates that glyphosate replaces herbicides that have toxicity ratings 3.4 to 16.8 times higher (Shutske, 2005).

In addition to permitting a shift to a more environmentally benign herbicide, glyphosate-tolerant soybeans led to a significant decrease in production costs. The herbicide cost for the biotech soybean crop represented an annual savings of $1.56 billion in production costs in spite of the additional investment in technology fees for biotech seed (Johnson et al., 2007).

Weed Resistance Requires Management

Glyphosate-tolerant crops – notably soybeans and corn, which are commonly rotated with each other in the Midwest, and glyphosate-tolerant cotton in the South – are increasingly being challenged by weeds resistant to glyphosate. Once considered a remote possibility, the specter of glyphosate-resistant weeds has become a harsh reality. Horseweed (marestail) exhibiting 8-to-13-fold resistance to glyphosate emerged in a Delaware soybean field in 2000 after three years of glyphosate-only weed management (VanGessel, 2001).



Since then, certain populations of an array of weeds have exhibited resistance, including giant ragweed, common ragweed, common waterhemp, Palmer amaranth, Italian ryegrass and Johnsongrass.

Resistant weeds are not a new phenomenon, and though disappointing, resistance to glyphosate does not eclipse the cost, management and environmental benefits of glyphosate-tolerant crops. However, it does require growers to employ other weed control tools where resistant populations are present or expected. They may need to draw from the arsenal of older herbicides that are effective against the resistant weed species, or consider adding glufosinate-tolerant crops (biotech varieties marketed as Liberty Link®), or forthcoming biotech crops tolerant to such classic herbicides as dicamba or 2,4-D to their crop rotation in order to bring another mode of action into their program.

Regardless of the development of weed resistance to herbicides, the net benefits of biotech herbicide-resistant crops remain positive.

Fewer Pounds of Active Ingredient

Among the most dramatic and immediate benefits of biotech input traits was a significant reduction in the use of herbicides and insecticides.

By 2006, 90 percent of the U.S. soybean crop was planted to herbicide-tolerant soybeans. That year, soybean growers reduced their herbicide usage by an average of 0.5 pounds of active ingredient per acre, or a total of 23 million pounds nationwide, compared to conventional herbicide programs (Johnson et al., 2007). That represents a reduction of nearly one-third of the average of 1.53 pounds per acre of herbicide active ingredient applied that year in conventional soybean programs.

Herbicide-tolerant cotton varieties reduced the amount of herbicide active ingredient applied to the cotton crop by 24.4 million pounds and saved cotton growers an estimated $230 million in weed control costs (Johnson et al., 2007).

Similarly, the adoption of Bt varieties of corn and cotton led to wide-scale reductions in insecticide use. For instance, Johnson et al. (2007) calculated that YieldGard® Bt corn planted on 16.6 million acres in 2006 to combat corn borer resulted in a nationwide increase in corn production of 65.1 million bushels, for a net return of $185 million – while reducing insecticide applications by a staggering 2.87 million pounds of active ingredient. The same year, cotton growers who planted Bt cotton varieties reduced insecticide use by 1.9 million pounds of active ingredient (Johnson et al., 2007).

Following the successful introductions of cotton Bt varieties targeted at the cotton bollworm complex and corn that expressed Bt crystals toxic to several species of corn borers, other Bt proteins, or events, were introduced. Events targeted at corn rootworm – a pest that forces growers to apply millions of pounds of soil insecticides and seed treatments per year in prophylactic applications – are among the most important new Bt genes. So are Bt events designed to minimize the risk of insect resistance among target *Lepidoptera*, as well as stacks of corn borer, cutworm and rootworm Bt events such as Dow AgroSciences' Herculex® XTRA.

Johnson and his team (2007) estimated that YieldGard RW corn, a family of Bt hybrids targeted at rootworm control, delivers a 5-percent improvement in yields over conventional insecticide treatments. In 2006, they calculated the 5-percent yield improvement totaled 3.3 million pounds (58,000 bushels) of corn on 7.7 million acres planted to the YieldGard RW hybrids. On that acreage, growers would have otherwise applied 3.9 million pounds of insecticide active ingredient to control rootworms, according to the researchers.

The Role of Conservation Tillage in Reducing Pesticide Movement

Conservation tillage plays an interesting role in reducing the chances of off-target movement of crop protection products. Because of their spectrum of control and the fact that they do not require incorporation into the soil, glyphosate and other postemergence herbicides are an excellent fit in conservation tillage and no-till systems. Glyphosate also rapidly becomes deactivated by quickly and tightly binding to soil particles, which reduces leaching. Conservation tillage systems significantly reduce soil erosion, so runoff of the herbicide molecules that are tightly bound to the soil is minimized.

Conservation tillage also tends to foster high populations of earthworms (Stinner and House, 1990). Earthworm burrows are lined with mucous that has been shown to adsorb pesticides. When the herbicide atrazine was poured down nightcrawler burrows, concentrations exiting at the bottom were reduced ten-fold (Stehouwer et al., 1994). Though not all studies demonstrate that no-till reduces pesticide leaching, the practice is widely recommended by water quality specialists because many studies have shown reductions in the movement of crop protection products through the soil where no-till is used (Gish et al., 1995; Novak, 1997).