Genetically engineered crops increase pesticide use in United States

*Agribusiness' claims that genetically engineered (GE) crops reduce pesticide use have been repeatedly challenged by their critics. A new report from **Chuck Benbrook** addresses this debate exploring the impact of GE corn, soybean, and cotton on pesticide use in the United States (US). Drawing principally on data from the US Department of Agriculture (USDA), Benbrook finds that GE crops have been responsible for an increase of 383 million pounds of herbicide use in the US over the first 13 years of commercial use (1996-2008). This dramatic increase swamps the decrease in insecticide use attributable to GE corn and cotton, making the overall chemical footprint of today's GE crops decidedly negative. The report identifies the primary cause of the increase - the emergence of herbicide-resistant weeds.*

The steep rise in the weight of herbicides applied to most GE crop acres is not news to farmers. Weed control is now widely acknowledged as a serious management problem within GE cropping systems. Farmers and weed scientists across the US Midwest and cotton belt are struggling to devise affordable and effective strategies to deal with the resistant weeds emerging in the wake of herbicide-tolerant crops. But skyrocketing herbicide use *is* news to the public at large, which still harbours the illusion, fed by misleading industry claims, that GE crops are reducing pesticide use. This claim was valid for the first few years of commercial use of GE corn, soybeans, and cotton. But this is no longer so.

In a recent story tracking the emergence of weeds resistant to glyphosate (Roundup), a North Carolina farmer said 'Roundup is the greatest thing in agriculture in my lifetime.' A retired weed scientist admits in the same story 'In hindsight, we screwed up. We can't rely on the same thing over and over.' But farmers did, turning glyphosate and GE corn, soybeans, and cotton into the most stunning market success story in the history of the pesticide and seed industry. GE seeds were introduced commercially in 1996 and now dominate the production of corn, soybeans, and cotton in the US. GE crops fall into one of two major categories: Herbicide-tolerant (HT) crops and Bt-crops. This report focuses on the impacts of these crops on pesticide use.

Study methodology

Official USDA surveys provide most of the data on the acres planted to each GE trait in corn, soybeans, and cotton. Annual 'trait acreage' reports from Monsanto provide more nuanced data on the acres planted to crops with specific traits and trait combinations. All of these data are high quality and are not controversial.

Pesticide use data are from the USDA's National Agricultural Statistics Service (NASS). Annual surveys show the percentage of crop acres treated with each pesticide active ingredient, average application rates, the number of applications, and weight of active ingredient applied. NASS pesticide use data are also of high quality, but do not report pesticide use separately on crop acres planted to GE seeds, as opposed to conventional seeds. Hence, a method was developed for each GE crop and trait to estimate from NASS data how much more or less pesticide was used on a GE acre versus a conventional acre.

Differences in pesticide use per acre are calculated by crop, trait, and year. The result is then multiplied by the acres planted to each GE crop trait in a given year. The model then adds the differences in the weight of pesticides applied across all crops, traits and years.

Expansion of GE plantings

Farmers planted 941 million acres of GE HT corn, soybeans, and cotton from 1996 through 2008. HT soybeans accounted for two-thirds of these acres. Bt corn and cotton were grown on 357 million acres, with corn accounting for 79% of these. Thus, about 1.3 billion trait acres of HT and Bt crops have been grown between 1996 and 2008. HT crops account for 72% of total GE crop trait acreage. The actual number of acres planted to GE soybeans, corn, and cotton over this period is considerably less than 1.3 billion due to the prevalence of 'stacked' versions of GE corn and cotton.

Impacts on pesticide use

GE crops reduced overall pesticide use in the first three years of commercial introduction (1996-1998) by 1.2%, 2.3%, and 2.3% per year, but increased pesticide use by 20% in 2007 and by 27% in 2008. Overall GE crops have increased pesticide use by 318.4 million pounds over the first 13 years of commercial use, compared to the amount of pesticide likely to have been applied in the absence of HT and Bt seeds.

Bt corn and cotton have delivered consistent reductions in insecticide use totaling 64.2 million pounds over the 13 years. Bt corn reduced insecticide use by 32.6 million pounds, or by about 0.1 pound per acre. Bt cotton reduced insecticide use by 31.6 million pounds, or about 0.4 pounds per acre planted.

However, HT crops have increased herbicide use by a total of 382.6 million pounds over 13 years. HT soybeans increased herbicide use by 351 pounds (about 0.55 pound per acre), accounting for 92% of the total increase in herbicide use across the three HT crops.

Recently herbicide use on GE acres has veered sharply upward. Crop years 2007 and 2008 accounted for 46% of the increase in herbicide use over 13 years across the three HT crops. Herbicide use on HT crops increased by 31.4% from 2007 to 2008.

Causes of high herbicide use

Two major factors are increasing the difference in the weight of herbicides used to control weeds on an acre planted to HT seeds, in comparison to conventional seeds:

- the emergence and rapid spread of weeds resistant to glyphosate, and
- incremental reductions in application rates of herbicides applied to non-GE crops.

Resistant Weeds

The widespread adoption of glyphosate-resistant (GR), Roundup Ready (RR) soybeans, corn, and cotton has vastly increased the use of glyphosate. Excessive reliance on glyphosate has spawned a growing epidemic of glyphosate-resistant weeds.

Glyphosate was used long before GE crops were planted. But GR weeds were practically unknown before the introduction of RR crops in 1996. Today, nine or more GR weeds collectively infest millions of acres of US cropland. Thousands of fields harbour two or more resistant weeds. The South is most heavily impacted, though resistant weeds are rapidly emerging in the Midwest, and as far

Definitions

A **trait** in a GE crop is the unique characteristic or attribute added to the genetic make-up of the crop using recombinant DNA (gene-splicing) technology.

Stacked GE seeds are those expressing two or more distinct traits.

Trait acres are the number of GE crop acres that contain a particular trait. One acre planted to a single-trait GE crop represents one trait acre, an acre planted to a "stacked" crop with two traits is equivalent to two trait acres, and so on.

Table 1. Percent of crop acres planted to HT and Bt crops

	1996	1999	2002	2005	2006	2007	2008
			All herbicide tolerant varieties				
Corn	3	8	11	26	36	52	63
Soybeans	7.4	55.8	75	87	89	91	92
Cotton	0.2	44	74	81	86	92	93
			All Bt varieties				
Corn	1.4	25.9	24	35	40	49	57
Cotton	12	31	39	60	65	72	73

north as Minnesota, Wisconsin, and Michigan.

Farmers can respond by:

- applying additional herbicide active ingredients,
- increasing herbicide application rates,
- making multiple applications of herbicides previously sprayed only once,
- greater reliance on tillage for weed control,
- manual weeding.

In the period covered by this report, the first three responses have been by far the most common, and each increases the weight of herbicides applied to HT crops.

GR pigweed (Palmer amaranth) has spread dramatically across the South since the first resistant populations were confirmed in 2005, and already poses a major threat to US cotton production. Some infestations are so severe that cotton farmers have been forced to abandon cropland, or resort to the preindustrial practice of hoeing weeds by hand. Resistant horseweed (marestail) is the most widespread and extensive glyphosate-resistant weed. It emerged first in Delaware in the year 2000, and now infests several million acres in at least 16 states of the South and Midwest, notably Illinois. GR horseweed, giant ragweed, common waterhemp, and six other weeds are not only driving substantial increases in the use of glyphosate, but also the increased use of more toxic herbicides, including paraquat and 2,4-D.

Growing reliance on older, higher-risk herbicides for management of resistant weeds on HT crop acres is now inevitable in the foreseeable future and will markedly deepen the environmental and public health footprint of weed management on over 100 million acres of US cropland.

Figure 1 shows the upward trend in the pounds of glyphosate applied per crop year across the three HT crops. The rate of glyphosate application per year has tripled on cotton farms, doubled in the case of soybeans, and risen 39% on corn. The average annual increase in the weight of glyphosate applied to cotton, soybeans, and corn has been 18.2%, 9.8%, and 4.3%, respectively, since HT crops were introduced.

Lower-dose herbicides used with conventional crops

The second key factor responsible for the increasing margin of difference in herbicide use on HT versus conventional crops is the discovery of more potent herbicide active ingredients. As a result, the average application rate of herbicides applied to conventional soybean acres dropped from 1.19 pounds of active ingredient per acre in 1996 to 0.49 pounds in 2008. The reduction in application rates accounts for roughly half of the difference in herbicide use on GE versus conventional soybean acres. The increase in the total weight of herbicides applied to HT soybean acres, from 0.89 pounds in 1996 to 1.65 pounds in 2008, accounts for the other half.

A similar trend is evident with insecticides. For example, insecticides targeting the corn rootworm (CRW) were applied at around 0.7 pound per acre in the mid-1990s and about 0.2 pound per acre a decade later.

The road ahead

The vast majority of corn, soybean, and cotton fields in the US in 2010 will be sown with GE seeds. This is not a bold prediction because the non-GE seed supply is so limited now that most farmers will be purchasing GE seeds, whether they want to or not. The GE corn, soybean, and cotton seeds planted over the next five to 10 years will, if current trends hold, contain increasing numbers of stacked traits (usually three or more), cost considerably more per acre, and pose unique resistance management, crop health, food safety, and environmental risks.

HT crops will continue to drive herbicide use up sharply, and those increases in the years ahead will continue to dwarf the reductions in insecticide use on Bt crop acres.

Tipping point for RR crops

However, 2009 will probably mark a tipping point for RR crops. The acres planted to HT soybeans fell 1% from the year before, and will likely fall further in 2010. Farmer demand for conventional soybeans is outstripping supply in several states, and universities and regional seed companies are working together to close the gap.

Reasons given by farmers for turning away from the RR system include the cost and challenges inherent in dealing with GR weeds, the increasing price of RR seeds, premium prices offered for non-GE soybeans, the poorer than expected yield performance of RR2 soybeans in 2009, and the ability of farmers to save and replant conventional seeds (illegal when purchasing HT/RR seeds).

In regions where farmers are combating resistant weeds, especially Palmer amaranth and horseweed in the South, university experts are projecting increases of up to US$80 per acre in costs associated with HT crops in 2010. This represents a remarkable 28% of soybean income per acre over operating costs, based on the USDA's optimistic forecast for 2010 soybean income (average yield 42 bushels at an average price of US$9.90 giving US$415.80 gross per acre).

The economic picture dramatically darkens for farmers combating resistant weeds under average soybean yields (36 bushels) and market prices (US$6.50 per bushel). Such average conditions would generate about US$234 in gross income per acre. The estimated US$80 increase in 2010 costs per acre of HT soybeans would then account for one-third of gross income per acre, and total cash operating costs would exceed US$200 per acre, leaving just US$34 to cover land, labour, management, debt, and all other fixed costs. This leaves little or no room for profit at the farm level.

The future for Bt

The future of Bt crops is brighter, but if and only if resistance is prevented. The seed industry, the Environmental Protection Agency (EPA), and university scientists have collaborated effectively in the last 13 years to closely monitor and prevent resistance to Bt.

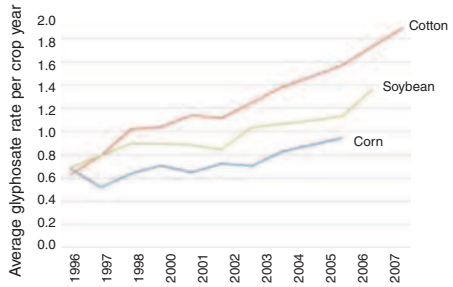
But now, some experts argue that the emphasis on resistance management in Bt crops can be relaxed. They point out that the trend in the seed industry toward stacking multiple Bt toxins in corn and cotton varieties should reduce the risk of resistance. The EPA has apparently been persuaded, since it has approved several recent Bt crops with substantially relaxed resistance management provisions.

History suggests that lessened diligence is premature. It took 10-15 years for corn and cotton insects to develop resistance to each new type of insecticide applied to control them since the 1950s.

Bt cotton has now been grown for 14 years, but the acreage planted did not reach one-third of national cotton acres until 2000. Plus, the first populations of Bt resistant bollworms were discovered in Mississippi and Arkansas cotton fields in 2003, about when experts predicted field resistance would emerge.

Bt corn for CRW control has been planted on significant acreage for only three years (2007-2009). Bt corn hybrids for Eastern corn borer (ECB) control are still planted on just a little over one-half national corn acres. For both types of Bt corn it is far too early to declare that resistance is no longer a significant threat.

Figure 1. Trend in glyphosate use



Future trends

Agricultural biotechnology firms have devoted the lion's share of their R&D resources to the development of only two biotech traits: herbicide tolerance and insect resistance. Pest control systems based on these traits are in jeopardy, for the simple reason that they foster near-exclusive reliance on single pest control agents – 'perfect storm' conditions for the evolution and spread of resistance.

Two major players in the industry – Monsanto and Syngenta – are now offering farmers rebates of around US$12 per acre to spray herbicides that work through a mode of action different from glyphosate. Monsanto will even pay farmers to purchase herbicides sold by competitors, a sign of how seriously Monsanto now views the threat that resistance poses to its bread and butter product lines.

The seed and pesticide industry sees new market opportunities and profit potential arising in the wake of resistant weeds. A large portion of industry R&D investments are now going into the development of crops that will either withstand higher rates of glyphosate applications, or tolerate applications of additional herbicides, or both. In short, the industry's response is more of the same.

One major biotech company has applied for and received a patent covering HT crops that can be directly sprayed with herbicide products falling within seven or more different herbicide families of chemistry. These next-generation HT crops will likely be sprayed with two or three times the number of herbicides typically applied today, and the total weight and cost of herbicides applied on HT crops will keep rising as a result. But despite these ill-conceived efforts, unmanageable weeds will almost certainly continue to spread.

Instead of just spraying more, farmers must diversify the tactics embedded in their weed management systems, alter crop rotations, scrupulously follow recommended herbicide resistance management plans, and utilize tillage more aggressively to bury herbicide-tolerant weed seeds deep enough to keep them from germinating.

Sustaining the efficacy of Bt crops is both important and possible. The emergence in 2003 of the first, isolated field populations of a major cotton insect resistant to Bt is troubling, but also reinforces the importance of today's resistance management plans, which have kept the resistant populations found in Mississippi and Arkansas from spreading.

Overall pesticide use is bound to continue rising on GE corn, soybeans, and cotton. Even if the new, multiple-toxin versions of Bt corn and cotton prove more effective in reducing insect pressure and feeding damage, the reduction in weight of insecticides achieved will be dwarfed by the continuing surge in herbicide use on HT crops.

The immediate and pressing goals for farmers, scientists and the seed industry include developing weed management systems capable of getting ahead of resistant weeds, assuring no lapse in the commitment to preserving the efficacy of Bt toxins, and expanding the supply and quality of conventional corn, soybean, and cotton seeds. The last goal will likely be the most vital, since the productivity of our agricultural system and the quality of much of our food begins with and depends on seeds.

The full report 'Impacts of Genetically Engineered Crops on Pesticide Use in the United States: The First Thirteen Years' is available at http://www.organic-center.org/reportfiles/13Years20091126_FullReport.pdf. The report was funded by a coalition of non-governmental organisations – the Union of Concerned Scientists, the Center for Food Safety, the Cornerstone Campaign, GE Policy Project, Greenpeace and Rural Advancement Foundation International – USA.

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Hundreds of apple farm workers poisoned in Chile

Two separate mass poisoning incidents occurred in recent months in Linares province, Maule Region, in central Chile. The first happened on 21 November 2009 on El Antojo farm in Yerbas Buenas district, when over 60 workers were affected by spraying operations in a neighbouring apple orchard. According to regional Occupational Health authorities, seven workers were taken to local clinics for medical attention. The second incident, on 23 November, involved 458 people affected by apple spraying on fields at Nueva Esperanza belonging to the Verfrut company near Longavi. 58 of these were treated in local clinics and Linares hospital and 400 were seen at an emergency field hospital set up in a nearby school, as clinic staff struggled to cope. Most of the people affected were farm workers who fell ill after inhaling pesticides recently applied and suffered respiratory problems, headache, dizziness and vomiting. Such was the scale of poisoning that the provincial governor, police, labour and health officials were called in and the health and labour authorities instigated actions against the fruit company and the ACHS mutual health insurance society, including a halt to field work in the affected areas. However, a few days later workers returned to the Nueva Esperanza fields and 40 experienced further poisoning symptoms, including two pregnant women.

Health authorities learnt that at Nueva Esperanza fields had been sprayed with the insecticide Pyrinex (chlorpyrifos) and the fungicide Clarinet (fluquinconazole and pyremethamil). While use of the neurotoxic organophosphate chlorpyrifos is restricted or prohibited for domestic and public health uses in the US, Argentina and Brazil, there are no such restrictions on its use in Chile. It is not known which pesticides were implicated in the Yerbas Buenas incident. Indeed, the ACHS insurance and Chile's state agricultural service (in charge of pesticide registration) both deny that the incidents were caused by pesticide poisoning, arguing that the farms were using authorised products, applied correctly and respecting re-entry safety periods. Health Ministry officials have contradicted these assumptions, based on their examinations, and suspect that workers were sent into treated fields before the safety period was over. National controversy over the incidents continues, with MPs and the bishop of Linares calling for better protection for farm workers.

PAN Chile has demanded urgent government actions to prevent further poisonings, with tougher controls on aerial and ground spraying and implementation of existing laws. The NGO highlights the continued high level of pesticide health incidents. Health Ministry data for 2008 report 849 confirmed cases of poisonings but estimate that only 25% of cases appear in official statistics, suggesting the reality is more likely to be over 3,000 per year. Partial figures for January to September 2009 record 340 cases and six fatalities.

In January 2010 another poisoning episode was reported, in Coltauco district in O' Higgins Region, when 40 women seasonal workers were almost directly oversprayed by a crop-dusting plane while they were working in vineyards of the Santa Rosa de la Agrícola Vial estate producing grapes for export. The women went to the ACHS with clear symptoms of acute intoxication (dizziness, fainting and vomiting), apparently affected by fungicide treatment only two hours earlier, although the regional regulations prescribe a four hour re-entry period. Furthermore, a second pesticide treatment was carried out close to where they were working. ' We were working and a mist of spray appeared. We all started to feel ill, dizzy and retching, they were spraying five metres away' said one worker. Again, the insurance society ACHS has denied any link with pesticides, claiming that the women suffered a 'collective anxiety attack'. However, a regional senator denounced the incident, asking how a company which exports fruits to overseas markets with strict standards can violate national standards.

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