THE CENTER FOR FOOD SAFETY

Center for Food Safety
660 Pennsylvania Ave., SE, Suite 302
Washington, DC 20003

June 7, 2010

National Institute of Food and Agriculture

RE: NIFA–2010–0001

Dr. Beachy:

The Center for Food Safety appreciates the opportunity to offer input on the Agriculture and Food Research Initiative (AFRI) of the National Institute for Food and Agriculture (NIFA).

CFS is greatly concerned that NIFA is turning away from the federal government's long-standing commitments to research and develop the techniques of integrated pest management (IPM) and educate farmers via extension services in their use. We are also dismayed by production agriculture's virtual abandonment of IPM. Our comments will focus on the need for NIFA to fund research and extension services into IPM.

(We use the term "pest" not in its colloquial sense, restricted to "insect pest," but rather in its scientific sense, to include any unwanted organism that causes damage to an agricultural crop. This includes not only insect herbivores and fungal pathogens of crops, but also weeds, which by competing with crop plants can reduce yield. Correspondingly, we use the term pesticide in its scientific rather than colloquial sense, as any compound designed to kill a pest, whether that pest is an insect, fungal pathogen, weed, etc. In the latter instance, the pesticide is known as an herbicide (i.e. weed-killer); and herbicides are thus a subset of pesticides. The term IPM, then, encompasses what has been called Integrated Weed Management (IWM). Below, our use of the term IPM should be understood to encompass IWM.)

Integrated Pest Management

IPM grew in the 1970s and 1980s from an understanding that a pesticide-only approach to pest control was counter-productive, in that it led to rapid evolution of resistance in pests, and a "pesticide treadmill" of increased pesticide use to simply maintain a given level of pest control. It also sprang from growing recognition of the harms to human (especially farmer) health and the environment from the massive pesticide use that characterizes American production agriculture.

These twin concerns spurred the development of IPM. A central principle of IPM is to employ a diversity of pest control methods that operate via different mechanisms so as to forestall evolution in the pest of "work-arounds" to any one of those methods. Rather than the sledgehammer blow of a single devastating chemical – an approach that is as extremely vulnerable to the longer-term evolution of pest resistance as it is effective at killing the pest in the short term – IPM consists of "many little hammers." The latter approach involves integrated application of several different techniques – each of which, taken individually, is only partially efficacious – that together provide adequate control of the pertinent pest.

"Adequate" rather than "total" control is another key principle of IPM, which aims to prevent not ALL pest damage, but rather economically significant damage. IPM recognizes that there are certain low to moderate levels of pest infestation, occurring at certain stages of the crop's growth, that do not reduce yield in any significant way, or at least not enough to justify the expense of control measures. Another benefit that flows from this awareness (beyond lesser use of and expenditure on pesticides) is lesser pressure for selection of pesticide-resistant pests.

IPM favors cultural and biological techniques over chemicals to control pests. Cultural methods to suppress pest populations include crop rotation, cover crops, intercropping, altering planting dates to "miss" pest emergence, and tillage. Biological methods include introduction of pest predators and disruption of pest mating cycles. Pesticides are de-emphasized both to forestall evolution of pest resistance and to mitigate harm to human health and the environment from their use. In its strongest and in our view best formulation, IPM implies that one turns to pesticides only as a last resort.

Both USDA and EPA have made formal commitments to promote IPM techniques. In 1977, the USDA adopted a policy to encourage use of integrated pest management in order to reduce chemical pesticide use and its associated risks. In 1993, USDA and EPA committed to a goal of 75% of U.S. cropland under integrated pest management by the year 2000.[1]

In 2001, the General Accounting Office (GAO) found that USDA and EPA had not made good on their commitments to foster IPM. While USDA estimated that 71% of U.S. cropland was managed using IPM practices in 2000, overall agricultural pesticide use increased by 40 million lbs. from 1992 to 2000, even as total cropland decreased. GAO found that USDA's overly expansive definition of IPM included measures – such as monitoring for pests and cleaning farm equipment – that, while useful, do not by themselves yield meaningful outcomes in terms of reduced pesticide use. For instance, while USDA estimated that 76% of corn was under integrated pest management in 2000, biological pest control was practiced on at most 18% of corn acres.[2]

---

[1] "Agricultural Pesticides: Management Improvements Needed to Further Promote Integrated Pest Management," Government Accounting Office, GAO-01-815, August 2001. http://www.gao.gov/new.items/d01815.pdf.

[2] See GAO report referenced in footnote 1.

<u>Agricultural Biotechnology Further Weakens IPM</u>

The introduction of the products of agricultural biotechnology has further weakened IPM efforts. Both major biotech traits, insect resistance and herbicide tolerance, contravene fundamental IPM principles. Both foster excessive reliance on pesticidal vs. cultural or biological approaches to pest control; and both are more conducive to "total" rather than "adequate" pest control. In both instances, superfluous selection pressure is exerted for propagation of resistant pests, and thus both are acutely prone to foster rapid evolution of pest resistance. Because of this proclivity to foster resistance, it is extremely important that cultivation of these crops be embedded in an integrated pest control strategy, if there is to be any hope of staving off the resistance that would render them obsolete.

IPM and Insect-Resistant Crops
Insect-resistant crops developed via agricultural biotechnology are presently limited to corn and cotton that express insecticidal toxins modeled on those produced by the soil bacterium, *Bacillus thuringiensis (Bt)*. These *Bt* toxins are constitutively expressed in all plant tissue. These toxins present greater risks of selecting for insects resistant to them than do topically applied, chemical insecticides in at least three important respects: temporal, spatial, and few modes of action.

First, Bt crops present susceptible insect pests with continual exposure to the insecticidal compound(s) throughout all or most of the growing season, whether the pests are present at economically damaging levels or not. Exposure is often constant over multiple growing seasons as well, in those increasingly common situations where a *Bt* crop is grown year after year. This contrasts sharply with the lesser temporal exposure to chemical pesticides, which are used sporadically, as needed, to control economically damaging levels of pests. Second, the presence of Bt insecticidal toxins in the more than 400 million acres of *Bt* corn and cotton grown since 1996 likely represents by far the most extensive exposure to any class of insecticidal compounds in the history of agriculture. Finally, selection pressure is increased by the prevalence of a few insecticidal compounds with very few different modes of action in commercially deployed Bt crops, in comparison to the many different modes of action of chemical insecticides. In short, Bt crops expose susceptible insect pests continuously, over vast expanses of land, to a very few insecticidal compounds, most of which have the same or similar mode of action. These three factors ensure enormously high selection pressure for development of pest resistance relative to chemical insecticides, "generating one of the largest selections for insect resistance ever known" (Tabashnik et al 2008).

Fortunately, EPA has undertaken steps to forestall evolution of insect resistance to Bt toxins. First, EPA required that growers of Bt crops also plant refugia of non-Bt crops in their fields to maintain populations of Bt-susceptible insects that can then mate with those that develop resistance to "dilute" resistance genes. This strategy is most effective when the resistance mechanism is controlled by a recessive allele, and is much less effective when resistance is dominant. Second, EPA has encouraged biotech companies to engineer crops for high-level expression of the insecticidal protein (EPA's "high-dose" strategy) to minimize survival of resistant individuals. Thus far, these efforts have been largely successful, although multiple populations of an extremely serious insect pest of corn, cotton and many other crops (*Helicoverpa zea*) have been documented with resistance to the Cry1Ac insecticidal toxin expressed in *Bt* cotton in Arkansas and Mississippi. Though limited at present, these resistant populations serve as a warning of the need to monitor for resistance and maintain resistance management measures such as refugia. EPA's recent weakening of refugia requirements in association with the multiple *Bt* toxin SmartStax corn is therefore premature, and of great concern. However, the remainder of our comments will focus on IPM as it relates to the other major biotech trait, herbicide resistance.

IPM and Herbicide-Resistant Crops

Herbicide-resistant (HR) crops must be understood as a system comprised of the herbicide-resistant seed and the herbicide it has been designed to withstand. In this sense, it is unlike Bt crops, where the technology is fully implemented in the seed itself. Weed scientists and regulators have consistently underestimated the extent to which the HR crop system is promoted and used as a complete, self-sufficient weed control package. Weed scientists have made the mostly false assumption that because HR crops ***can*** be used with herbicides other than the one they are engineered to withstand, farmers will use multiple herbicides to stave off weed resistance. Regulators at USDA (gatekeeper re: biotech crops) have refused to even consider use of the HR crop-associated herbicide in conducting environmental assessments of HR crops, dealing with the HR crop weed control system as if the seed's HR trait had nothing to do with the herbicide the crop is engineered to be used with. These failures of judgment on the part of weed scientists and federal regulators have facilitated the unregulated use of HR crop systems that in turn has driven an epidemic of resistant weeds.

At present, the vast majority of HR crops are Monsanto's glyphosate-tolerant, Roundup Ready varieties of soybeans, corn, cotton, canola and sugar beets. Fourteen years of extensive use has demonstrated quite clearly that growers use the Roundup Ready system as it was intended to be used, as they were told to use it. In the words of Monsanto: "The utilization of Roundup agricultural herbicides plus Roundup Ready soybean, collectively referred to as the Roundup Ready soybean system…" (Monsanto 2006, p. 4). Monsanto sponsored advertising ("advertorials") in farm journals featuring one of the only weed scientists in America who agreed with Monsanto's mistaken (and self-serving) notion that a "glyphosate-only" approach to weed control (i.e. use of the Roundup Ready system year after year) would not foster glyphosate-resistant weeds (Hartzler 2004). The fallacy of this approach to weed control is now abundantly evident, as glyphosate-resistant weeds reach epidemic proportions (e.g. Attachment 1).

The "solutions" to glyphosate-resistant weeds being developed and introduced by pesticide-biotech-seed companies involve crops that have enhanced glyphosate-resistance and resistance to multiple herbicides (usually including glyphosate) (Benbrook 2009, Chapter 7). See Attachment 2 for a partial list of such HR crops in the near-term pipeline.

Some (for instance, DuPont-Pioneer employee Jerry M. Green) have presented these multiple HR crops as viable solutions to glyphosate-resistant weeds, even using the language of "diversity" (reminiscent of IPM's emphasis on utilizing diverse pest management tactics) to language to justify them (Green 2009). It must be emphasized that multiple HR crops are deeply at odds with integrated pest management, and in fact will take American agriculture ever further from IPM deeper into pesticide dependence.

First, multiple HR crops violate IPM's commitment to prioritize non-chemical approaches to pest control. In the case of weeds, viable methods include crop rotation and cover crops, both of which have multiple benefits beyond weed control. The herbicide-only approach to weeds that is fostered by the multiple HR crop paradigm will increase herbicide use, pollution and its impacts on the environment, the presence of herbicides in our surface and drinking water, and herbicide residues on crops and in our food. This is NOT the path forward for weed control. In fact, the pesticide companies are very explicitly taking us ***backwards***, by developing crops resistant to older, more toxic herbicides like 2,4-D (part of the Vietnam War defoliant, Agent Orange) and dicamba (a chlorophenoxy herbicide closely akin to 2,4-D).

Second, multiple HR crops may well merely buy a little time, at the longer-term cost of losing the HR crop-associated herbicides due to rapid evolution of weed resistance. This would render them less efficacious or ineffective for ***proper, sparing*** use in the context of an IPM approach. Multiple herbicide-resistant weeds are on the rise. For instance, several of the more recent glyphosate-resistant weed populations exhibit dual tolerance to ALS inhibitors or to paraquat.[3] Premix herbicide products comprising glyphosate and an ALS inhibitor are being marketed now as a solution to glyphosate-resistant weeds, but may have the unintentional effect of selecting for still more weed populations with dual resistance to both.

Populations of the most damaging corn/soybean weed in much of the Corn Belt (tall waterhemp) with triple herbicide resistance to glyphosate, ALS inhibitors and PPO inhibitors have been identified in Missouri (Legleiter & Bradley 2008) and with triple resistance to ALS inhibitors, PPO inhibitors and triazines in Illinois (Patzoldt et al 2005). The triple-HR weeds in Missouri have been expanding at a rapid clip, and were recently estimated to have expanded from a few thousand acres to infest anywhere from 100,000 to 1,000,000 million acres in Missouri.[4] In Illinois, the triple-resistant population reported in Patzoldt et al (2005) was treated with glyphosate in the context of GR crop systems, whereby it evolved resistance to glyphosate as well, for quad-resistance, in 23 counties. Weed scientists in Missouri and Illinois say they are rapidly running out of chemical control options.

These examples illustrate the principle that weeds can and do evolve resistance to multiple herbicides. In most cases, this appears to happen through successive selection of already

[3] See entries marked in red with "Multiple – 2 MOA's" at http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=12&FmHRACGroup=Go.
[4] http://www.weedscience.org/Case/Case.asp?ResistID=5269.

resistant weeds for multiple resistance. Thus, waterhemp and many other weeds evolved extensive resistance to ALS inhibitors in the 1980s and 1990s (one reason for the success of Roundup Ready crops). Glyphosate use with Roundup Ready crops selected for dual-resistance from the ALS inhibitor-resistant populations.

Another known mechanism of weed resistance is metabolic resistance. Here, weeds evolve degradation mechanisms that are effective against a range of herbicides. Known mechanisms include plant cytochrome P450 enzymes (general purpose detoxification enzymes, which have analogues in humans, where they are concentrated in the liver) and glutathione S-transferase enzymes. (This is in contrast to "target-site" resistance, where the resistance is specific to a particular herbicide or class of herbicides). Based on current knowledge, metabolic resistance is most common in grass weeds (vs. dicots), and has been found more in Europe than the U.S. (Powles & Yu 2010). However, weed resistance mechanisms in many cases remain unknown, and new herbicide resistance mechanisms (in weeds) are being discovered.

Our significant level of ignorance in this area urges caution. American agriculture is about to be launched, willy-nilly, into an era of multiple HR crops. We need to take a time-out to conduct further research into weed resistance, to get a better handle on the ramifications of engineering and deploying crops with resistance to multiple herbicides. A few key questions are as follows: Will these multiple HR crops engender weeds resistant to multiple herbicides? What costs are imposed on growers of non-HR crops whose appropriate, sparing use of herbicides is being threatened by weed resistance driven by HR crop systems? What regulatory alternatives might be available to forestall weed resistance and extend the life of valuable herbicides for all farmers?

Meanwhile, NIFA should provide ample funding for research and extension services in the field of integrated weed management. Clearly, weed control in the U.S. is overwhelmingly dominated by herbicides, and current trends are making our agriculture still more herbicide-dependent. No true "diversification" can take place within this "herbicide-only" paradigm.

One example provides a signpost for the way forward. Glyphosate-resistant Palmer amaranth is devastating cotton and increasingly soybean production in the Southeast and mid-South. Growers utilize six to eight herbicides in often futile attempts to control this rapidly-growing, incredibly competitive weed. EPA felt compelled to reverse a ban on toxic organic arsenical herbicides for use in cotton (other uses are still being phased out) for the express purpose of giving cotton growers another tool to battle resistant Palmer amaranth.[5] There is now a substantial trend among growers to revert to tillage to control these and other (e.g. horseweed) glyphosate-resistant biotypes, increasing soil erosion. In some cases, growers are even reverting to the practice of chopping cotton. These are all sad instances of how the latest technology (Roundup Ready), when not properly

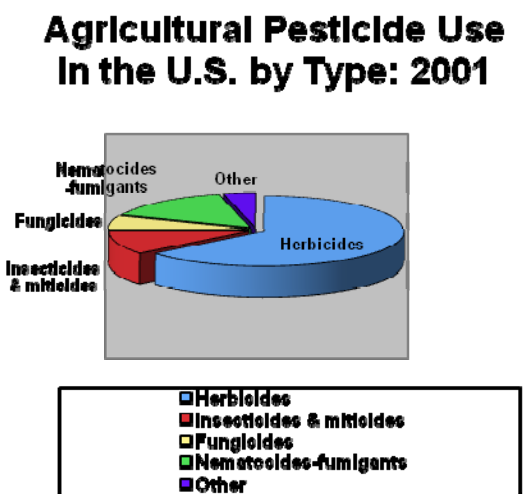
[5] EPA Arsenic (2009). "Amendment to Organic Arsenicals RED," Letter from EPA's Richard P. Keigwin, Director, Special Review and Reregistration Division, to Registrant, April 22, 2009.

stewarded, can quickly be rendered obsolescent, necessitating a return to (much) earlier and either more damaging or less desirable techniques.

Due to the inefficacy and/or undesirability of these approaches to controlling glyphosate-resistant Palmer amaranth, interest has grown in a cover-cropping solution born of research by USDA ARS scientist Andrew Price. Price has experimented with use of various cover crops – for instance, rye and black oats – in cotton and soybean systems to gauge their efficacy at suppressing weeds in general, and glyphosate-resistant Palmer amaranth in particular (Price et al 2006; Reeves et al 2005; Attachment 3). This work has attracted the notice of Stanley Culpepper, University of Georgia weed scientist, and other cotton experts who are promoting it as one approach to controlling glyphosate-resistant Palmer's amaranth (Nichols et al 2008).

Pesticides and Human Health

Herbicides comprise nearly 2/3 of American agricultural use of pesticides (433 of 675 million lbs. in 2001), nearly six-fold greater than the insecticides that many associate with the term pesticide. Many pesticides, including some herbicides, are hazardous compounds, associated with increased risk of cancer (President's Cancer Panel 2010) and other harms to human health, such as endocrine disruption.[6]



Source: "Pesticides Industry Sales and Usage: 2000 and 2001 Market Estimates," U.S. Environmental Protection Agency, May 2004, Table 3.4. http://www.epa.gov/oppbead1/pestsales/01pestsales/market_estimates2001.pdf.

We urge NIFA to make integrated weed management a top priority for AFRI and for extension services, in order to give farmers tools to manage weeds without exclusive or primary resort to chemical weed control, and to mitigate the substantial burden imposed by herbicides on human health and the environment.

[6] See, generally, www.ourstolenfuture.org.

Sincerely,

Bill Freese, Science Policy Analyst
Center for Food Safety

References

Benbrook, C. (2009). The Impact of Genetically Engineered Crops on Pesticide Use in the United States: The First Thirteen Years," The Organic Center, November 2009. http://www.organic-center.org/science.pest.php?action=view&report_id=159.

Green, J.M. (2009). "Evolution of glyphosate-resistant crop technology," *Weed Science* 57:108–117.

Hartzler, B. (2004). "Two for the price of one," Iowa State University, Dec. 17, 2004. http://www.weeds.iastate.edu/mgmt/2004/twoforone.shtml.

Legleiter, T.R. & K.W. Bradley (2008). "Glyphosate and Multiple Herbicide Resistance in Common Waterhemp (Amaranthus rudis) Populations from Missouri," *Weed Science* 56: 582-87.

Monsanto (2006). "Petition for the Determination of Nonregulated Status for Roundup RReady2Yield Soybean MON 89788," submitted to USDA 6/27/06, revised 11/3/06, Monsanto Company. http://www.aphis.usda.gov/brs/aphisdocs/06_17801p.pdf.

Nichols, R.L. et al (2008). "Glyphosate-Resistant Populations of *Amaranthus palmeri* Prove Difficult to Control in the Southern United States," Power Point Presentation by 10 weed scientists, see: http://www.cottoninc.com/Weed_Management/Glyphosate-Resistant-Populations-US/Glyphosate-Resistant-Populations-US.pdf.

Patzoldt, W.I. et al (2005). "A waterhemp (Amaranthus tuberculatus) biotype with multiple resistance across three herbicide sites of action," *Weed Science*, 53:30–36.

Powles, S.B. & Q. Yu (2010). "Evolution in Action: Plants Resistant to Herbicides," *Ann. Rev. Plant Biol.* 61: 8.1-8.31.

President's Cancer Panel (2010). "Reducing Environmental Cancer Risk: What We Can Do Now," National Institutes of Health, National Cancer Institute, 2008-2009 Annual Report, April 2010.

Price, A. J., D. W. Reeves, and M. G. Patterson (2006). "Evaluation of three winter cereals for weed control in conservation-tillage non-transgenic soybean," *Renewable Agric. and Food Sys.* 21:159-164.

Reeves et al (2005). "Evaluation of Three Winter Cereals for Weed Control in Conservation-Tillage Nontransgenic Cotton," *Weed Technology* 19: 731-736.

Roberson, R. (2010). "Herbicide resistance finding troublesome," Southeast Farm Press, Jan. 19, 2010. http://southeastfarmpress.com/cotton/herbicide-resistance-0119/

Tabashnik et al (2008). "Insect resistance to Bt crops: evidence versus theory," *Nature Biotechnology*, Vol. 26, No. 2: 199-202.

Attachment 1

New York Times – May 4, 2010, page B1

http://www.nytimes.com/2010/05/04/business/energy-environment/04weed.html?hp=&pagewanted=print

U.S. Farmers Cope With Roundup-Resistant Weeds

By WILLIAM NEUMAN and ANDREW POLLACK

DYERSBURG, Tenn. — For 15 years, Eddie Anderson, a farmer, has been a strict adherent of no-till agriculture, an environmentally friendly technique that all but eliminates plowing to curb erosion and the harmful runoff of fertilizers and pesticides.

But not this year.

On a recent afternoon here, Mr. Anderson watched as tractors crisscrossed a rolling field — plowing and mixing herbicides into the soil to kill weeds where soybeans will soon be planted.

Just as the heavy use of antibiotics contributed to the rise of drug-resistant supergerms, American farmers' near-ubiquitous use of the weedkiller Roundup has led to the rapid growth of tenacious new superweeds.

To fight them, Mr. Anderson and farmers throughout the East, Midwest and South are being forced to spray fields with more toxic herbicides, pull weeds by hand and return to more labor-intensive methods like regular plowing.

"We're back to where we were 20 years ago," said Mr. Anderson, who will plow about one-third of his 3,000 acres of soybean fields this spring, more than he has in years. "We're trying to find out what works."

Farm experts say that such efforts could lead to higher food prices, lower crop yields, rising farm costs and more pollution of land and water.

"It is the single largest threat to production agriculture that we have ever seen," said Andrew Wargo III, the president of the Arkansas Association of Conservation Districts.

The first resistant species to pose a serious threat to agriculture was spotted in a Delaware soybean field in 2000. Since then, the problem has spread, with 10 resistant species in at least 22 states infesting millions of acres, predominantly soybeans, cotton and corn.

The superweeds could temper American agriculture's enthusiasm for some genetically modified crops. Soybeans, corn and cotton that are engineered to survive spraying with

Roundup have become standard in American fields. However, if Roundup doesn't kill the weeds, farmers have little incentive to spend the extra money for the special seeds.

Roundup — originally made by Monsanto but now also sold by others under the generic name glyphosate — has been little short of a miracle chemical for farmers. It kills a broad spectrum of weeds, is easy and safe to work with, and breaks down quickly, reducing its environmental impact.

Sales took off in the late 1990s, after Monsanto created its brand of Roundup Ready crops that were genetically modified to tolerate the chemical, allowing farmers to spray their fields to kill the weeds while leaving the crop unharmed. Today, Roundup Ready crops account for about 90 percent of the soybeans and 70 percent of the corn and cotton grown in the United States.

But farmers sprayed so much Roundup that weeds quickly evolved to survive it. "What we're talking about here is Darwinian evolution in fast-forward," Mike Owen, a weed scientist at Iowa State University, said.

Now, Roundup-resistant weeds like horseweed and giant ragweed are forcing farmers to go back to more expensive techniques that they had long ago abandoned.

Mr. Anderson, the farmer, is wrestling with a particularly tenacious species of glyphosate-resistant pest called Palmer amaranth, or pigweed, whose resistant form began seriously infesting farms in western Tennessee only last year.

Pigweed can grow three inches a day and reach seven feet or more, choking out crops; it is so sturdy that it can damage harvesting equipment. In an attempt to kill the pest before it becomes that big, Mr. Anderson and his neighbors are plowing their fields and mixing herbicides into the soil.

That threatens to reverse one of the agricultural advances bolstered by the Roundup revolution: minimum-till farming. By combining Roundup and Roundup Ready crops, farmers did not have to plow under the weeds to control them. That reduced erosion, the runoff of chemicals into waterways and the use of fuel for tractors.

If frequent plowing becomes necessary again, "that is certainly a major concern for our environment," Ken Smith, a weed scientist at the University of Arkansas, said. In addition, some critics of genetically engineered crops say that the use of extra herbicides, including some old ones that are less environmentally tolerable than Roundup, belies the claims made by the biotechnology industry that its crops would be better for the environment.

"The biotech industry is taking us into a more pesticide-dependent agriculture when they've always promised, and we need to be going in, the opposite direction," said Bill Freese, a science policy analyst for the Center for Food Safety in Washington.

So far, weed scientists estimate that the total amount of United States farmland afflicted by Roundup-resistant weeds is relatively small — seven million to 10 million acres, according to Ian Heap, director of the International Survey of Herbicide Resistant Weeds, which is financed by the agricultural chemical industry. There are roughly 170 million acres planted with corn, soybeans and cotton, the crops most affected.

Roundup-resistant weeds are also found in several other countries, including Australia, China and Brazil, according to the survey.

Monsanto, which once argued that resistance would not become a major problem, now cautions against exaggerating its impact. “It’s a serious issue, but it’s manageable,” said Rick Cole, who manages weed resistance issues in the United States for the company.

Of course, Monsanto stands to lose a lot of business if farmers use less Roundup and Roundup Ready seeds.

“You’re having to add another product with the Roundup to kill your weeds,” said Steve Doster, a corn and soybean farmer in Barnum, Iowa. “So then why are we buying the Roundup Ready product?”

Monsanto argues that Roundup still controls hundreds of weeds. But the company is concerned enough about the problem that it is taking the extraordinary step of subsidizing cotton farmers’ purchases of competing herbicides to supplement Roundup.

Monsanto and other agricultural biotech companies are also developing genetically engineered crops resistant to other herbicides.

Bayer is already selling cotton and soybeans resistant to glufosinate, another weedkiller. Monsanto’s newest corn is tolerant of both glyphosate and glufosinate, and the company is developing crops resistant to dicamba, an older pesticide. Syngenta is developing soybeans tolerant of its Callisto product. And Dow Chemical is developing corn and soybeans resistant to 2,4-D, a component of Agent Orange, the defoliant used in the Vietnam War.

Still, scientists and farmers say that glyphosate is a once-in-a-century discovery, and steps need to be taken to preserve its effectiveness.

Glyphosate “is as important for reliable global food production as penicillin is for battling disease,” Stephen B. Powles, an Australian weed expert, wrote in a commentary in January in The Proceedings of the National Academy of Sciences.

The National Research Council, which advises the federal government on scientific matters, sounded its own warning last month, saying that the emergence of resistant weeds jeopardized the substantial benefits that genetically engineered crops were providing to farmers and the environment.

Weed scientists are urging farmers to alternate glyphosate with other herbicides. But the price of glyphosate has been falling as competition increases from generic versions, encouraging farmers to keep relying on it.

Something needs to be done, said Louie Perry Jr., a cotton grower whose great-great-grandfather started his farm in Moultrie, Ga., in 1830.

Georgia has been one of the states hit hardest by Roundup-resistant pigweed, and Mr. Perry said the pest could pose as big a threat to cotton farming in the South as the beetle that devastated the industry in the early 20th century.

“If we don’t whip this thing, it’s going to be like the boll weevil did to cotton,” said Mr. Perry, who is also chairman of the Georgia Cotton Commission. “It will take it away.”

William Neuman reported from Dyersburg, Tenn., and Andrew Pollack from Los Angeles

Attachment 2

Center for Food Safety Work Product – May 2010

Herbicide-Tolerant Crops in the Near-Term Pipeline as of May 3, 2010

http://www.aphis.usda.gov/brs/not_reg.html

The glyphosate-resistant weed epidemic triggered by continual glyphosate use with Roundup Ready crops is driving the pesticide-biotech industry's product pipeline. Below, eight HT crops pending deregulation (i.e. approval for commercial cultivation) by USDA, some resistant to 2 or 3 herbicide classes. In addition, 5 of the 8 GE crops deregulated since 2005 have been herbicide-resistant. See next pages for further information.

Petition No.	Company	Crop / Transf. Event	Phenotype	Comments
Eight Herbicide-Tolerant Crops Pending Grant of Nonregulated Status by USDA as of May 3, 2010				
09-349-01p	Dow	Soybean DAS-68416-4 (see below)	Triple herbicide tolerant	Tolerates 3 classes of herbicide: phenoxy auxins (e.g. 2,4-D, MCPA), aryloxyphenoxypropionates (ACCase inhibitors) and glufosinate. 2,4-D was part of the dioxin-laced, Vietnam War defoliant Agent Orange, and is strongly linked to increased incidence of cancer in pesticide applicators.
09-328-01p	Bayer	Soybean FG72	Double herbicide tolerant	Tolerates glyphosate and HPPD inhibitors. Bayer, like Stine Seed and DuPont (see below) have developed their own glyphosate-tolerant crops, a development that will hasten the already rapid emergence of glyphosate-resistant weeds.
09-233-01p	Dow	Corn DAS-40278-9	Double herbicide tolerant	Tolerates phenoxy auxins (e.g. 2,4-D, MCPA) and aryloxyphenoxypropionates (ACCase inhibitors). 2,4-D was part of the dioxin-laced, Vietnam War defoliant Agent Orange, and is strongly linked to increased incidence of cancer in pesticide applicators.
09-063-01p	Stine Seed	Corn HCEM485	Glyphosate tolerant	Appears to be a variation on Monsanto's glyphosate-insensitive CP4 EPSPS enzyme. As Monsanto's competitors introduce glyphosate-tolerant crops, there will be fewer conventional, non-glyphosate-tolerant options.
09-015-01p	BASF	Soybean BPS-CV127-9	Imidazolinone-tolerant	Imidazolinones are a class of ALS inhibitor herbicides. More species of weed have developed resistance to ALS inhibitors than to any other family of herbicides. A damaging corn weed (common waterhemp) resistant to glyphosate, ALS inhibitors and one or two other herbicide classes has evolved in Missouri (triple-resistant) and Illinois (quad-resistant).
08-340-01p	Bayer	Cotton T304-40XGHB119	Glufosinate tolerant; insect resistant	Bayer is the developer of a glufosinate-tolerant, LibertyLink line of crops that the company is marketing as a way for farmers to tackle glyphosate-resistant weeds. As with other herbicide-tolerant crop offerings, the likely result is weed populations resistant to multiple herbicides.

04-110-01p	Monsanto & Forage Genetics	Alfalfa J101, J163	Glyphosate tolerant	In 2006, a federal district court reversed USDA's original approval of Roundup Ready alfalfa; once again being considered for deregulation after a court-ordered, but deeply flawed, Environmental Impact Statement
03-104-01p	Monsanto & Scotts	Creeping bentgrass ASR368	Glyphosate tolerant	In 2006, a federal district court ruled that USDA's failure to assess field trials of glyphosate-tolerant creeping bentgrass for environmental impacts violated federal law. Research by EPA has shown pollen and seeds from such field trials can travel for miles, resulting in weedy glyphosate-resistant hybrids and bentgrass plants that cannot be killed with glyphosate.

Dow Agroscience's triple herbicide-resistant DAS-68416-4 soybeans

* USDA describes these soybeans as "2,4-D and glufosinate tolerant."[7] This description is not quite accurate. A search on the event name "DAS-68416-4," a unique identifier, turns up a Japanese field trial application with the following information (http://www.bch.biodic.go.jp/download/en_lmo/DAS68416enUR.pdf):

"Soybean tolerant to aryloxyalkanoate herbicide and glufosinate herbicide (Modified aad-12, pat, Glycine max (L.) Merr.)"

* Aryloxyalkanoates are a broad cross-cutting class of herbicides that include some ACCase inhibitors (i.e. aryloxyphenoxypropionates) as well as phenoxy auxin herbicides like 2,4-D and MCPA. Thus, these soybeans are resistant to herbicides from at least three different herbicide families (ACCase inhibitors, phenoxy auxins and glufosinate: see below under "Corn DAS-40278-9").

Dow Agroscience's dual herbicide-tolerant DAS-40278-9 corn

* USDA describes this corn as "2,4-D and ACCase-inhibitor tolerant" (see footnote 1). In fact, it contains the same aryloxyalkanoate herbicide tolerance as Dow's triple herbicide-resistant soybeans (see above), lending this corn resistance to phenoxy auxins like 2,4-D and many but not all ACCase-inhibiting herbicides. A search on the event name "DAS-40278-9," a unique identifier, turns up the following abstract.

http://www.weeds.iastate.edu/NCWSS2009/Abstracts/011.pdf
PERFORMANCE OF DOW AGROSCIENCES HERBICIDE TOLERANCE TRAIT IN CORN. Mark A. Peterson, David M. Simpson, Cory Cui, Eric F. Scherder, David C. Ruen, John S. Richburg, Sam M. Ferguson, Patricia L. Prasifka and Terry R. Wright, Dow AgroSciences, Indianapolis, IN 46268.

Dow AgroSciences has introduced two new herbicide tolerance traits, commonly referred to Dow AgroSciences Herbicide Tolerance (DHT) traits. DHT1 trait is currently being developed in corn. The DHT1 trait is a synthetic gene developed by Dow AgroSciences from *Sphingobium herbicidovorans. In planta* this gene produces an enzyme that metabolizes several herbicides having an aryloxyalkanoate moiety, including Phenoxy auxins (e.g., 2,4-D, MCPA) and aryloxyphenoxypropionates (e.g., quizalofop, haloxyfop). **DHT1 corn events have been tested in the field and demonstrated robust tolerance to preemergence, single postemergence, and sequential postemergence applications of 2,4-D at 1120, 2240 and 4480 g ae/ha [Note from B. Freese: These rates, expressed in grams of acid equivalents per hectare, are equivalent to 1, 2 and 4 lbs. per acre, respectively, a hefty dose of 2,4-D, given that 2,4-D is typically applied a rates of 0.3 to 1 lb. per acre, as can be verified by searching on 2,4-D at http://www.pestmanagement.info/nass/app_usage.cfm].**

Postemergence applications of quizalofop of up to 184 g ai/ha have also been well tolerated by DHT1 corn events. Corn growth, development, maturity and yield of individual

---

[5] See http://www.aphis.usda.gov/brs/not_reg.html.

events are equivalent to iso-lines. DHT1 may also be stacked with other herbicide resistance traits to improve and enhance the performance of current weed control systems, improve the control of "hard to kill" broadleaf weeds, and prevent or delay the onset of herbicide resistant weeds.

Bayer CropScience's FG72 soybeans:

* USDA describes these soybeans as "glyphosate and isoxaflutole tolerant" (see ft. 1). A search on the event name "FG72," a unique identifier, turns up http://www.inspection.gc.ca/english/plaveg/bio/subs/2010/20100317e.shtml, which has the following information:

* The CFIA and Health Canada have received a submission from MS Technologies LLC and Bayer CropScience Inc. seeking an approval for unconfined environmental release (including for import purposes) and livestock feed and food use of soybean designated as **Double-Herbicide-Tolerant Soybean Event FG72**, which has been **genetically engineered for tolerance to glyphosate and HPPD inhibitor herbicides**.

* Isoxaflutole is one of several herbicides of the HPPD inhibitor class, which act by depleting plant tissues of protective pigments, resulting in bleaching of young tissue which leaves the plant vulnerable to damage by light. HPPD inhibitors are one of only two classes of herbicides (the other being glutamine synthetase inhibitors (glufosinate)) to which weeds have yet to evolve resistance, but weed scientists are very concerned that resistance to this class will evolve as well. Making a plant tolerant to an herbicide is an invitation for over-reliance on that pesticide to the exclusion of other weed control methods, chemical or cultural. Cultural methods of weed control – too little used, often ignored by extension agents and farmers alike – include planting of cover crops that exude allelopathic compounds that suppress weeds quite effectively in follow-on crops, and crop rotations that break weed cycles and are advisable for other reasons.

BASF Plant Science's BPS-CV127-9 Soybean

* USDA lists these soybeans as "imidazolinone tolerant" (see ft. 1)

* Imidazolinones are one class of acetolactate synthase (ALS) inhibiting herbicides. Multiple populations of 108 species of weeds have evolved resistance to ALS inhibitors worldwide, more than to any other family of herbicides. See: http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=3&FmHRACGroup=Go and http://www.weedscience.org/ChronMOA.GIF

* The first ALS inhibiting herbicide was introduced in 1982, followed by the first report of weed resistance just five years later in 1987. Rapid adoption of Roundup Ready crops beginning in the 1990s was in part due to widespread weed resistance to ALS inhibitors – a classic example of the pesticide treadmill: See: Benbrook (2009). "Impact of Genetically Engineered Crops on Pesticide Use: The First 13 Years," The Organic Center, November 2009, pages 12-14, Figure 2.4. http://www.organic-center.org/science.pest.php?action=view&report_id=159.

Other herbicide-resistant crops from Monsanto and collaborators:

* SmartStax corn from Monsanto and Dow, introduced this year, are resistant to glyphosate and glufosinate (i.e. Liberty or a new formulation called Ignite, from Bayer CropScience)

* Dicamba-tolerant soybeans from Monsanto, in collaboration with BASF, the largest manufacturer of dicamba. See: Behrens, M.R. et al (2008). "Dicamba resistance: enlarging and preserving biotechnology-based weed management strategies," *Science* 316: 1185-1188; and Service, R.F. (2008). "A growing threat down on the farm," *Science* 316: 1114-1117. In this latter article, eminent weed scientist Stephen Powles predicts that glyphosate-resistant weeds will reach epidemic proportions in a few years time. The future is now.

* Dicamba-tolerance will be stacked with glyphosate tolerance. See "BASF and Monsanto formalize agreement to develop dicamba-based formulation technologies," Press Release, Jan. 20, 2009, http://monsanto.mediaroom.com/index.php?s=43&item=683

* The potential for vastly increased use of dicamba is concerning because of "revolatilization" issues. Dicamba, once applied, will under the right conditions revolatilize and drift long distances, damaging neighboring crops.

* Dicamba- & Glufosinate-tolerant corn, which would apparently also be glyphosate-tolerant, for triple herbicide resistance: "This next-generation herbicide-tolerant corn product builds on the Roundup Ready® platform and would provide farmers with additional herbicide tolerance options. See: http://monsanto.mediaroom.com/index.php?s=43&item=788

* Triple resistant cotton: Dicamba, glufosinate, and glyphosate: see http://monsanto.mediaroom.com/index.php?s=43&item=788

* Corn tolerant to "FOPS" herbicides and glyphosate. FOPS is shorthand for aryloxyphenoxypropionates (see Dow triple-resistant soybeans and dual-resistant corn above). FOPS are considered "high resistance risk" herbicides due to rapid evolution of weed resistance with their use. For example, see: http://www.efarming.com.au/News/announcements/2269/dim-future-for-fop-herbicides-in-wa.html and http://www.hgca.com/publications/documents/cropresearch/Paper_12_Stephen_Moss.pdf