Thoughts on the Recent National Research Council Report: Let's Put Glyphosate Weed Resistance in Perspective

By Dr. Thomas Bauman, Purdue University Weed Scientist

Speeches are being made lamenting that glyphosate is on its last legs. A recent National Research Council report, *The Impact of Genetically Engineered Crops on Farm Sustainability in the United States,* warned that weed resistance to glyphosate may force farmers to return to tillage as a weed management tool – reversing the trend toward more conservation tillage.

I share the National Research Council's concern over evolving weed resistance to glyphosate, and, its recommendation that we need to change the way we are managing genetically engineered (GE) cultivars if we hope to keep them for long. I also share the Council's view that one of glyphosate technology's major benefits has been that it has given farmers the ability to manage weeds in a way that they could implement conservation tillage. Conservation tillage has increased the retention of water in the soil, while substantially reducing soil erosion — agriculture's number one pollution problem.

However, I don't think farmers need to start cleaning off their moldboard plows and chisels. Glyphosate is still an excellent weed control tool for U.S. farmers.

Following are my views on the options available to farmers to suppress the development of new resistant weeds to glyphosate, control weed species already glyphosate resistant, and a look at new products in the pipeline that will greatly help farmers do both. And, I'll conclude with why, because of nature, we need continued development of new weed control technologies and practices.

Glyphosate in Perspective

To put glyphosate's current situation in perspective, the National Research Council report lists 16 weeds worldwide resistant to glyphosate — only nine in the United States. Those nine are rigid ryegrass, horseweed also known as marestail, Italian ryegrass, hairy fleabane, common ragweed, giant ragweed, Johnsongrass, Palmer amaranth also known as Palmer pigweed, and common waterhemp. More recently three additional weeds — one (kochia) in the United States — have been determined to be glyphosate resistant bringing the total to 19 weeds worldwide and 10 in the United States. The fact that only 10 weeds have been found glyphosate resistant in the U.S. means there are many weeds that can still be effectively controlled by glyphosate.

In addition, some of the resistance in those glyphosate-resistant weed species is at a very low level and can be controlled by applying higher rates of glyphosate.

In other cases, farmers can still control some of those resistant weeds by improving their application management – specifically by making application at the right time, at the right rate. But the length of time glyphosate will remain an excellent weed control tool for farmers depends on whether they change their weed control programs.

Changes are needed. I don't think we could have designed a system more ideal for getting weed resistance than the one we have now – which is minimal or no tillage to suppress weeds and the use of one product with one mode of action sprayed over the top with no soil activity.

Adopting this system and expecting we wouldn't have weed resistance in the future was probably unrealistic from the start. Considering the number of acres we have been treating since glyphosate was introduced in 1996 in Roundup Ready crops, it's somewhat surprising we haven't had more weed resistance exhibited.

How Weed Resistance Evolves

In talking about weed resistance, it's important to understand how it evolves. Weeds don't mutate and suddenly become a resistant superweed. Rather, there is a weed out there in a population of millions of weeds in a field that won't be controlled by a particular herbicide product. If we continuously use the same herbicide to treat that weed species in these fields, over time, the surviving resistant individuals will multiply and become the predominant species in your field because the herbicide you were using took out all of the susceptible ones.

This selection process takes time, maybe 6 to 8 years of continuous use of a single herbicide mode of action, before the resistant biotype becomes prevalent and the problem is noticed.

Managing Weed Resistance

This process can be effectively delayed for many years by applying herbicides with multiple modes of action. These alternate herbicides suppress the weeds resistant to one of the other modes of action thus keeping them from multiplying, or at least multiplying quickly. Applying herbicides with other modes of action is also how farmers can suppress glyphosate-resistant weeds that have already become major problems in their fields.

Farmers have several options available to attack weeds with different modes of action. One option is to use Ignite herbicide in conjunction with the LibertyLink trait. We have not yet seen weed resistance to that technology. Seed companies are helping make that option more convenient to use by increasingly placing both the LibertyLink and Roundup Ready genes in the same hybrid. This enables farmers to use Roundup one year and Ignite the next without changing hybrids.

Other options are to tank mix products with multiple modes of action with glyphosate to give post-emergence activity against those resistant weed species. And in some cases farmers can control resistant weeds with soil products.

Challenge: Farmer Implementation

The challenge is getting farmers to implement these options that utilize additional modes of action. Incorporating soil-applied materials or post-emergent tank mixes in weed control programs is more expensive, and less flexible in terms of application timing, than using glyphosate with glyphosate-resistant crops. And that's the "rub" as I see it.

Glyphosate Resistant Weeds

Rigid ryegrass*	1996
Goosegrass	1997
Horseweed*	2000
Italian ryegrass*	2001
Hairy fleabane*	2003
Buckhorn plantain	2003
Common ragweed*	2004
Giant ragweed*	2004
Ragweed parthenium	2004
Johnsongrass*	2005
Palmer amaranth*	2005
Common waterhemp*	2005
Sourgrass	2006
Wild poinsettia	2006
Junglerice	2007
Kochia*	2007
Liverseedgrass	2008
Perennial ryegrass	2008
Sumatran fleabane	2009

***United States**
3 grasses, 7 broadleaves
Worldwide
8 grasses, 11 broadleaves
19 species/15 years=1.3/year

Source: Purdue University

Palmer Amaranth

While the increased cost is a major impediment, application flexibility is also a big issue. Once farmers start planting in the spring, they don't want to stop until the seed is all in the ground, because they don't know when rains are coming. If they have to also spray at the same time, that's going to slow down their planting operations – something they're not willing to do in most cases. I understand their reasoning to some degree.

The most effective way to get farmers to rotate modes of action is to make effective, easy to manage and cost-competitive weed control products with multiple modes of action available to them.

There is a great deal of research and development being undertaken to find these products – products that can be rotated with glyphosate to control the development of resistance.

One new product that is advanced in development is 2,4-D tolerant corn and soybeans that will be used in combination with a new 2,4-D herbicide based on the proven 2,4-D chemistry that was so effective in the past. If approved, that technology should control the glyphosate-resistant broadleaves we currently have as well as those that develop in the future.

If we get into more grass-resistant weeds, then it's a little cloudier, but one technology in development would incorporate the ability to use post-emergence grass materials over corn. We can already use them over soybeans, but not grass crops. If this technology makes it to the marketplace, it would enable farmers to spray their corn over the top for both broadleaf and grass weeds that might have glyphosate resistance.

Need New Products

Research and development of new products are essential, as nature has proven to be a tough foe when it comes to weed control. No matter what herbicide or weed management technology we have used from the modern era of 1940 or 1950 to today, all of them have met, or created, challenges over time. There are three reasons this happens.

First, we get resistant weeds. Resistance to glyphosate is currently on everyone's mind, but we have also seen weed resistance evolve with the triazines, ALS inhibitors, ACC inhibitors, and there's evolving resistance to paraquat on a worldwide basis. We have seen some resistance develop for almost every class of herbicide we've had – the exceptions being one or two that were recently introduced, and I would suspect resistance will also develop for them if they are used on enough acreage over a long enough period of time.

Secondly, there are weed shifts. These herbicides don't control weeds equally well, and so weed pressure shifts. A classic example of weed shift was when 2,4-D came out years ago. We went from a broadleaf problem to a grass problem because 2,4-D provided excellent control of broadleaves. Use of 2,4-D created a void and nature filled it with foxtails and other weedy species. Similarly, black nightshade became a bigger problem after Treflan and Sencor became available, because neither of these products were particularly effective in controlling it.

A third reason is that sometimes we just build a better mousetrap. The glyphosate-resistant crop system is superior in so many ways that farmers widely adopted it and reduced or eliminated their use of herbicides with other modes of action. In 2009, GE crops accounted for more than 80 percent of United States soybean, corn and cotton acreage. Ironically, its success is likely bringing on resistance problems quicker than if it had not been such a superior product.

Waterhemp

Another result of the success of herbicide resistant technology — and a concern of mine — is that the shift to using this technology to control weeds has greatly reduced the interest of many companies in investing in finding and developing new herbicide products. They understandably question if they will be able to recover a $200 to $300 million investment to develop a new herbicide that would have to compete with herbicide-resistant crop products. I should note that these companies also realize there are fewer new modes of action out there to be discovered and developed, and their opportunities of finding new herbicides that farmers will be able to afford are more difficult.

And, so today we have fewer companies and discovery groups looking for new herbicide products than in the past. And, we don't see new groups of products in the pipeline – products with different modes of action that we may need some day to fight weed resistance. Therefore it's important that we work to preserve the tools we have today and find more effective ways to use them.

Note: You can read the full National Research Council report, *The Impact of Genetically Engineered Crops on Farm Sustainability in the United States,* online at: **http://www.nap.edu/catalog.php?record_id=12804**.

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