

MANAGING

Weed Resistance

FOR HIGHER YIELD

Stewardship Keeps Technology Working for You



January 2012

DEVELOPING RESISTANCE

It's happened in Iowa. It's happened to glyphosate, just as it happened to triazines, ALS inhibitors, HPPD inhibitors, ACCase inhibitors and PPO inhibitors. Glyphosate resistance is here, and it's here to stay.

The emergence of Iowa populations of waterhemp, giant ragweed and horseweed (or marestalk) resistant to glyphosate really isn't much of a surprise. There are currently 19 different types of weeds resistant to at least one herbicide in the state. Glyphosate has been nearly the only herbicide many growers have used since Roundup Ready soybeans were introduced in 1996, so many of the weeds left standing have been the ones that can survive a dose or more of the broad-spectrum treatment. If ever there was a laboratory experiment to demonstrate how continuous selection with a single herbicide can select for resistant populations, this was it.

Weed scientists aren't sure how many acres in Iowa are harboring resistant weeds at this point, but the outlook isn't good. It's likely that you have resistant biotypes on your farm already or you're just a season or two away from battling them, says Mike Owen, Extension weed specialist at Iowa State University, so your herbicide program has to grow to include a wider range of herbicides. Now.

There are clear lessons from other states, where farmers have been grappling with glyphosate resistance for years. Some growers have had to abandon fields to resistant weeds, regroup, and resume the battle. All have had to adjust their expectations about the time, effort and expense required for weed control and the results older weed control programs can deliver. And they all share a similar warning.

Eric Prostko, Extension weed specialist at the University of Georgia in Tifton, Ga., sounds like a biblical prophet when he shares his insight with Iowa farmers.

"One year we thought it was bad. The next year it was a disaster," Prostko says. "Before you get to where we are, change what you're doing."

It's a good bet that ALS resistant common waterhemp is on your farm, says Owen, and that glyphosate resistant waterhemp is also present or close by.



Photo: Iowa State University

Waterhemp can produce more than 500,000 seeds per plant and seedlings can emerge throughout the growing season.

"Three years ago, we collected 200 populations of waterhemp from around the state," he says. "Fully one-third of them appeared to have glyphosate resistance." Owen adds that resistance to glyphosate in the state's waterhemp population is overlaid on top of existing resistance to ALS inhibitors like Classic™ or Pursuit™, a condition called multiple resistance that limits control options.

Waterhemp is especially prone to evolving multiple resistance because it always cross pollinates, creating a very diverse gene pool and encouraging the spread of resistant genes. In fact, scientists in Illinois have identified individual waterhemp plants that are resistant to at least four different herbicide families at the same time.

"Farmers won't realize they have a problem until about 30 percent of the population has the trait," says Owen. "By that time, you've gone through a couple of years of seeding the field with resistant plants and you've got a big problem."

Spreading Resistance

Glyphosate resistant weeds can appear in your fields two ways: if you independently select for resistance through the repeated use of glyphosate, or if they are

transported by pollen or seed from another field where a resistant population has taken hold.

Unfortunately, horseweed, waterhemp and giant ragweed are not only prone to evolving resistance, they can be highly mobile. That means even if you do everything right to avoid selecting for resistance, you could still end up with resistant weeds in your fields.

A horseweed seed can drift for miles or float on floodwaters from field to field. The tiny, hard-hulled seeds of waterhemp and other pigweeds can hitch a ride on boots, hooves, truck tires and farm equipment. Even more frightening, airborne waterhemp pollen can spread resistant genes about three miles per year, according to a gene flow model developed at the University of Illinois, and many people suspect the pollen could be traveling even farther. Windblown giant ragweed pollen can also confer resistance to plants miles away.

Higher Input Costs

Johnny Dodson has battled glyphosate resistant weeds for years on his 1,500 acres near Halls, Tenn. "It's terribly expensive," he warns. "We're using a whole host of chemistries from Ignite in burndown programs to multiple residuals. We're spending \$60 to \$70 an acre where we used to spend \$6 to \$10 an acre."



Photo: Iowa State University

Horseweed is often referred to as marestail.

Needless to say, losing glyphosate as a stand-alone herbicide changes the profitability picture for soybeans. It also requires much more management.

Dodson applies Dual™ in corn and soybeans, along with atrazine in corn. In tilled fields, he'll pre-plant incorporate Treflan™ and Prowl™, then follow up with postemergence tankmixes. On some farms – especially cotton and wide-row soybeans – he'll even run a tractor with four seats mounted on a toolbar up

"Farmers won't realize they have a problem until about 30 percent of the population has the trait."

**– Mike Owen
Iowa State University**



Photo: Mark Jackson

front so workers can spot-spray Palmer pigweed with a tankmix of Gramoxone™ and Valor™.

Glyphosate resistant Palmer pigweed, a cousin of waterhemp, is a terrifying foe. With hundreds of thousands of seeds per plant, a quickly adapting genetic base and stems that can get as thick as a small tree trunk, this weed provides a sobering view of the power of the pigweed family.

"The last five years, all we talk about is pigweed," says Prostko in Georgia, where glyphosate resistance in Palmer pigweed was confirmed in 2005. "We're saying a residual herbicide should be used on every acre automatically. We need at least one, and we may need two in some fields. But it's not just herbicide. We talk about the impact of tillage. There's also rotation. Corn is a great rotation crop because you can use atrazine."

Plan A, Plan B, Plan C

Closer to the Iowa border, Weed Scientist Bryan Young of Southern Illinois University in Carbondale, Ill., has been helping growers combat glyphosate resistant horseweed, waterhemp and giant ragweed for more than five years. He warns Iowa growers to expect their herbicide costs to triple or quadruple, application windows to shrink and time spent scouting and spraying to multiply.

"Start clean and stay clean," Young advises. "Use the best residual herbicide for your primary weed – in this case, waterhemp – and apply it as close to planting as possible. We need as much residual control as we can get."

Starting clean begins with a full labeled rate of a preplant or preemergence herbicide, he says. "This is not the time to be cutting rates," says Young. "Use the rate that will give you the level of control you want. If you don't do things at the right time or the weather doesn't cooperate, you may have to change your system. You have to have an adaptive weed management program. You have to have a Plan A, a Plan B and a Plan C."

Think carefully about your backup strategies, Young notes. The days of going after foot-tall weeds with a postemergence application are over.

"A rescue treatment is not a plan," he says.

Divide and Conquer

In Tennessee, Dodson analyzes each of his fields and manages them according to differences in soils, tillage



"The resources expended in weed management will pay back multi-fold because you will protect yield."

- Mike Owen,
Iowa State University

programs, rotation and weed pressure. Mike Owen says that's exactly where Iowa growers need to start.

"Do you put the same hybrid on all your acres? Why not?" Owen says. "Diversifying risk. Should the same fertilizer program be on all acres? Soil types vary, and so do nutrient requirements and rotations. So why spray the same herbicide on all acres? Weeds are just like crops. They vary from field to field."

Multiple Modes of Action

The one thing every field should see is multiple modes of action, Owen emphasizes. "Every time you do something, you need to have multiple modes of action in the tank," he says. The big, red flag is making sure you're not applying a mode of action to which the target weed is already resistant. If you spray waterhemp with an ALS/glyphosate tankmix, it's just as bad as using glyphosate alone.

Instead, use a DNA (or "yellow") herbicide, a triazine or a chloracetamide where waterhemp is a problem, he suggests; include 2,4-D in your springtime program where horseweed is a threat in corn. Owen is a fan of an early preplant application in March or April, which can provide an early jump on weeds, take advantage of spring rainfall and allow farmers to focus on planting as the weather gets better. The key is choosing the right herbicide for the weeds, soils and timing at hand.

"Think about, 'what do I really not want in my field?' and pick a soil-applied residual herbicide that targets those weeds," Owen says. "Think, 'what weeds do I have that are already resistant?' and get them out of the way."

Shelia Hebenstreit has taken that multiple modes-of-action approach for years on her own farm and on the farms of the customers she serves as an agronomist for West Central Cooperative in Jefferson, Iowa. On the corn side of the rotation, she often employs three modes of action at once.

"I've been in preventative medicine, I guess, as opposed to curative," says Hebenstreit. "I don't want to

get to the point where I'm trying to cure this."

Shifting to a reliance on soil-applied herbicides adds flexibility to postemergence programs, adds Wayne Fredericks, who farms near Osage, Iowa. He believes that if he doesn't already have glyphosate resistant waterhemp on parts of his 975-acre operation, it's not far away. "We stress that we have a clean seedbed by emergence," he notes. "Then we try to properly time our postemergence application to not let the weeds get beyond their effective control size. The use of preemergence herbicides buys you a little time."

There are other benefits to going back to soil-applied herbicides.

For one thing, it's well documented that controlling weeds early reduces the early-season competition that chips steadily away at yield. "The money expended will pay back multi-fold because you will protect yield," says Owen.

New Genetics

Many growers are eagerly awaiting new soybean varieties with built-in resistance to 2,4-D or dicamba. Those new genetics are likely a couple of seasons away from the market, says Owen, and they offer challenges of their own.

"There's the potential for drift of these herbicides," he cautions. "And chances are they're not going to have the 98-percent market share that glyphosate resistant beans have now, so it will be absolutely critical to make sure you're spraying the right field, and spray tank contamination will become a huge issue."

University of Tennessee's Tom Mueller adds another reality check. "They will be very good tools, but the size limitation on weeds for dicamba or 2,4-D will be a challenge to many farmers. They want to kill very big weeds like they used to with Roundup, and for many farmers, those days are gone."

Why Waterhemp?

When it comes to herbicide resistance, waterhemp often finds its way to the head of the class. The species has evolved resistance to at least five different herbicide families in the past couple of decades.

An individual waterhemp plant can produce as many as 1 million seeds, each one tiny and rugged enough to hitch a ride for miles on a combine, a boot or a cow's hoof. Mature waterhemp plants can tower overhead, or they can head out at less than a foot tall, deep beneath the canopy – whatever it takes to create the next generation.

Waterhemp is a dioecious plant, with separate male and female plants. That means waterhemp pollen is designed to travel, blowing easily on the wind to spread genes miles at a time. Plants that cross-pollinate like waterhemp tend to develop highly diverse gene pools. That increases the odds of spreading resistance genes, or just creating new ones.



Seedhead and flowers of waterhemp

Photo: Iowa State University



"The way I'm looking at it, I have to be the good steward here, locally. I have to manage my own backyard and do the best I can. The ultimate responsibility lies with the farmer."

- Shelia Hebenstreit,
Jefferson, Iowa

No Cavalry Coming

If the story of glyphosate were an old-fashioned cowboy movie, this would be the part where the cavalry would come charging over the hill to rescue the beleaguered hero.

Don't listen for bugles. There's no cavalry coming, no miracle herbicides in the pipeline to deliver a new mode of action and save us from weed resistance. We're down to the tools we already have, coupled with the knowledge farmers can apply to solving the problem and a strong commitment to good stewardship to help those tools stay as sharp as possible. The more tools we lose to resistance, the more we erode at the profit margin of soybeans and corn. Resistance management is good economic stewardship as well as ecological stewardship.

"The way I'm looking at it, I have to be the good steward here, locally," says Hebenstreit. "I have to manage my own backyard and do the best I can. The ultimate responsibility lies with the farmer."

If you think you have resistant weeds, talk to someone – a neighbor, an agronomist or an extension agent, urges David Wright, director of contract research and strategic initiatives for the Iowa Soybean Association. "The emergence of a resistant weed population on your farm isn't a mark of shame, and it doesn't make you a bad farmer," says Wright. "But it does mean you need to kick your weed management program into high gear. Get help planning an



"Get help planning an effective multi-pronged weed management program. Even if you don't have resistant weeds on your farm now, change your approach so you don't face a disaster later."

- David Wright,
Iowa Soybean Association

effective multi-pronged weed management program. Even if you don't have resistant weeds on your farm now, change your approach so you don't face a disaster later."

Nobody agrees with that more than Johnny Dodson in Tennessee.

"The best way to avoid this train wreck is to start alternating your chemicals before you even develop the problem," Dodson says. "Alternate modes of action, use residuals – spend the money now and make an investment in the future.

"If you continue to do business the way you've done it and you think you're going to avoid a resistance issue," he warns, "you're wrong. Dead wrong."

Other Technologies are Being Challenged, Too

Glyphosate isn't the only stalwart crop protection product encountering resistance in the Midwest. Single-mode-of-action Bt corn hybrids are starting to come under attack by western corn rootworm populations that have found a way to defeat the crop's built-in defenses. Resistance is also starting to appear in populations of the fungus that causes frogeye leaf spot.

The same dynamics apply in Bt corn as in a soybean field facing glyphosate resistance, notes Erin Hodgson, Extension entomologist at Iowa State University.

"Farmers that are in continuous corn and are using the same Bt traits year after year are losing that performance," Hodgson says. "It all goes back to being proactive, always mixing things up so you're confusing the pest. If you're not mixing it up, you can't expect tools to last long."



Rootworm damage to rootworm resistant corn plant (right)

Photo: Erin Hodgson, Iowa State University

Rotating to soybeans is the best way to break the resistance cycle with the new rootworm populations, says Hodgson. Switching among corn rootworm Bt traits is an important step, especially in continuous corn. If you suspect that your rootworm population is becoming resistant to your Bt hybrid, she adds, alternate the Bt trait and apply a full labeled rate of insecticide seed treatment to add another mode of action to your program.

Resistance also works the same way among pathogens, notes Carl Bradley, Extension plant pathologist at the University of Illinois. In many ways, the fungus that causes frogeye leaf spot is a lot like waterhemp, he points out.

"There's a lot of genetic diversity in that fungus," says Bradley. "The more genetic diversity there is in the pathogen population, the more likely it is some resistant individuals are just lurking out there in the field. When you apply the same mode of action again and again, you start selecting for those resistant individuals. It doesn't matter if you're looking at insects or weeds or fungi; we can't just rely on one tool to control these complex biological organisms. Integrated management is important for all of them."

Just as an infestation of glyphosate resistant weeds can seem to appear overnight after building up for several years, pathogen and insect populations can also shift unseen.

The lesson is that stewardship principles are the same across the board, says Wright.

"In fact, using only chemical tactics to manage pests, without the inclusion of cultural and mechanical control tactics, will inevitably fail and the pest complex will adapt," Wright notes. "Nature will always find a way around it. As stewards of these tools, we need to manage them well to keep them viable for the long haul, even if that means putting them aside or investing in supplemental controls in the short term."



"It all goes back to being proactive, always mixing things up so you're confusing the pest. If you're not mixing it up, you can't expect tools to last long."

- Erin Hodgson,
Iowa State University

Photo: Iowa State University



Giant ragweed can spread resistant genes by wind.

As Easy As 1, 2, 3

It's been a long time since many growers have taken the time to sort through once-familiar herbicides like metribuzin, trifluralin and dicamba, let alone try to remember how each one acts on target weeds. With a dizzying array of product names and premixes, the market is flooded with options. It's downright confusing.

That's why American chemical companies have adopted a global system of classifying modes of action in numbered groups, which makes mixing and matching modes of action literally as easy as 1, 2, 3. For instance, any member of the ALS inhibitor family is identified as a Group 2 herbicide; glyphosate is in Group 9.

Remember, almost all waterhemp populations are resistant to ALS-inhibiting herbicides. Any new resistance that evolves in waterhemp (i.e. glyphosate) will make the waterhemp population multiple resistant to both ALS and the other herbicide mechanism(s) of action. That is why it is important to understand the mode of action of the herbicides you use in your soybean and corn production systems. Your crops may change from year-to-year but the weeds, and the herbicides to which they are resistant, don't.

Visit www.iasoybeans.com/productionresearch/ for an online, color-coded chart that lists soybean and corn herbicides by their mode of action and site of action group number. It assists the user with options to rotate among herbicides with different sites of action to delay the development of herbicide resistance.

Additional Resources

www.weeds.iastate.edu
www.glyphosateweedscrops.org
www.weedscience.org
www.planthealth.info
www.iasoybeans.com/productionresearch/

Acknowledgments

Mike Owen, Iowa State University
Erin Hodgson, Iowa State University
Kristine Schaefer, Iowa State University
Eric Prostko, University of Georgia
Bryan Young, Southern Illinois University
Carl Bradley, University of Illinois
Tom Mueller, University of Tennessee
Steve Werblow, Werblow Communications

Remember:
Stewardship keeps technology
working for YOU.