Integrated weed management best response to herbicide resistance

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Over-reliance on glyphosate-type herbicides for weed control on U.S. farms has created a dramatic increase in the number of genetically-resistant weeds, according to a team of agricultural researchers, who say the solution lies in an integrated weed management program.

"I'm deeply concerned when I see figures that herbicide use could double in the next decade," said David Mortensen, professor of weed ecology, Penn State.

Since the mid-1990s, agricultural seed companies developed and marketed seeds that were genetically modified to resist herbicides such as Roundup -- glyphosate -- as a more flexible way to manage weeds, Mortensen said. About 95 percent of the current soybean crop is modified by inserting herbicide-resistant genes into the plants.

"We do understand why farmers would use the glyphosate and glyphosate-resistant crop package," Mortensen said. "It is simple and relatively cheap, but we have to think about the long-term consequences."

The researchers said that increased use of herbicider is leading to more species of weeds that also are resistant to the chemicals.

They report their findings in the current issue of *BioScience*, noting that 21 different weed species have evolved resistance to several glyphosate herbicides, 75 percent of which have been documented since 2005,

despite company-sponsored research that the resistance would not occur.

"Several species have developed amazing biochemical ways to resist the effects of the herbicide," said J. Franklin Egan, doctoral student in ecology, Penn State. "If weed problems are addressed just with herbicides, evolution will win."

One way the weeds develop resistance is to make an enzyme that is insensitive to the herbicide, but still maintains cellular function, Egan said. Weeds have also developed ways for the plant to move the herbicide away from targeted enzymes.

"For instance, glyphosate-resistant strains of Conyza canadensis -- horseweed -- sequester glyphosate in leaf tissues that are exposed to an herbicide spray so that the glyphosate can be slowly translocated throughout the plant at non-toxic concentrations," Egan said. "To the horseweed, this controlled translocation process means the difference between taking many shots of whiskey on an empty stomach versus sipping wine with a meal."

In response to the increasing number of weeds resistant to current applications, companies are developing new generations of seeds genetically modified to resist multiple herbicides. This continual insertion of more genes into crops is not a sustainable solution to herbicide resistance, according to the researchers. They add that companies are creating a genetic modification treadmill similar to the pesticide treadmill experienced in the mid-20th century, when companies produced increasingly more toxic substances to manage pests resistant to pesticides.

"Specifically, several companies are actively developing crops that can resist glyphosate, 2, 4-D and Dicamba herbicides," said Mortensen. "Such genetic manipulation makes it possible to use herbicides on these

crops that previously would have killed or injured them. What is more troubling is that 2,4-D and Dicamba are older and less environmentally friendly."

Egan said there are several problems with the treadmill response. First, weeds will eventually evolve combined resistance to Dicamba, 2,4-D and glyphosate herbicides. Globally, there are already many examples of weeds simultaneously resistant to two or more herbicides.

Increased use of 2,4-D and Dicamba applied over the growing corn and soybean means much more of these herbicides will be applied at a time of year when many sensitive crops like tomato and grapes are most vulnerable to injury. Such injury results when these herbicides move from the targeted field during or following an application.

Overuse of chemical weed killers may increase chances that farmers will use the herbicide during inappropriate or non-recommended weather conditions, leading to herbicides drifting from the targeted area and killing or harming other plants and crops.

Egan also said that if farms become too reliant on herbicides, farmers will find it more difficult to use integrated weed management approaches.

Integrated weed management includes planting cover crops, rotating crops and using mechanical weed control methods. Farmers can use herbicides in this management approach, but must use them in a targeted, judicious fashion.

The researchers, who also worked with Bruce D. Maxwell, professor of land resources and environmental sciences, Montana State University, Matthew R. Ryan, post-doctoral student, Penn State, and Richard G. Smith, assistant professor of agroecology, University of New Hampshire,

said that in previous studies, integrated weed management had lowered herbicide use by as much as 94 percent while maintaining profit margins for the operations.

"Integrated weed management is really the path forward," said Egan. "We believe these methods can be implemented, and we already have a lot of show that they're effective and straight forward to incorporate."

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