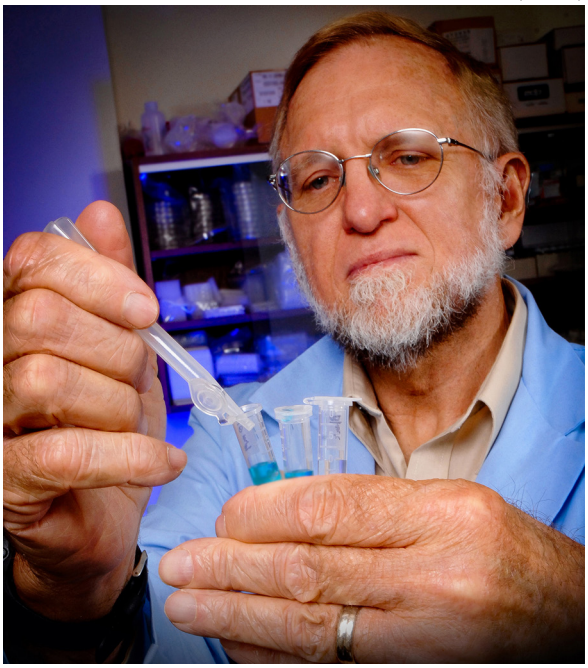
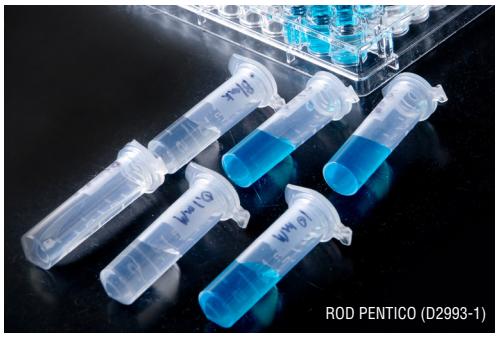
Fighting Back Against Glyphosate Resistance

ROD PENTICO (D2992-1)



In Fort Collins, Colorado, plant physiologist Dale Shaner uses a dye test to detect the compound shikimate in plant leaves. Measuring this compound can determine whether a weed will resist the herbicide glyphosate.

Below: Tubes with blue color tested positive for shikimate, and the clear liquid was a negative result.



ROD PENTICO (D2993-1)

Success sometimes comes with a price.

The herbicide glyphosate is highly effective at controlling a broad spectrum of weeds in gardens and on farms. It has been sold for many years in products known commercially as "Roundup" and is used with conventional crops and with varieties of corn, cotton, soybeans, and canola that were developed specifically to withstand glyphosate.

Glyphosate use also has environmental benefits, such as simplifying weed control in reduced-tillage farming. It has allowed growers to switch from conventional tillage practices to no-till systems that reduce labor costs, improve soil quality, and help curb soil erosion. About 93 percent of soybeans, 78 percent of upland cotton, and 70 percent of corn produced in the United States in 2010 were glyphosate-tolerant varieties.

Glyphosate's popularity, and the common practice of using it with no other herbicides, has led to the emergence of a dozen glyphosate-resistant weeds. Growers who stop using glyphosate often go back to tilling their soil, reversing the improvements in soil quality seen over the past decade.

"Widespread use of glyphosate, often to the exclusion of other herbicides, ensured that weeds capable of surviving glyphosate would thrive. Now that we're seeing that happen, we need to address it," says Dale Shaner, a plant physiologist who recently retired from the Agricultural Research Service Water Management Research Unit, in Fort Collins, Colorado.

Shaner is working as a collaborator with Monsanto to develop a kit that growers could use to determine whether weeds in their fields are glyphosate resistant. Thomas Potter, an environmental chemist at the ARS Southeast Watershed Research Laboratory in Tifton, Georgia, is evaluating an herbicide that some cotton growers are using as an alternative.

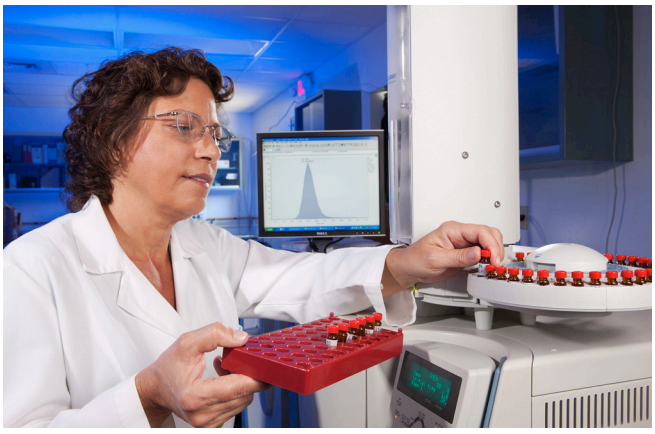
Value of Early Detection

One key to addressing the threat posed by glyphosate resistance is early detection.

"If resistant weeds are detected early, you can minimize the problem by either using another herbicide or, in the case of palmer amaranth, one of the most difficult weeds to control, getting into the field to pull it out." Shaner says.

Scientists can determine whether a weed will resist glyphosate by measuring the amount of a compound known as "shikimate" in its tissues. Glyphosate kills weeds by interfering with production of aromatic amino acids, and shikimate plays a key role in producing those amino acids. It is the "shikimate pathway" that glyphosate disrupts, causing shikimate to accumulate. Plants susceptible to glyphosate will have high levels of shikimate, while resistant plants will not.

In Tifton, Georgia, technician Sally Belflower loads soil sample extracts into an autosampler of a gas chromatograph-mass spectrometer to test for herbicide residues.



PEGGY GREB (D2959-1)

Existing methods for detecting shikimate in plants require sophisticated laboratory equipment, such as spectrophotometers that can measure ultraviolet light. Test results can take weeks.

Now, Monsanto has developed a method for detecting shikimate in just 24 hours, using a dye that changes color. Shaner plans to help Monsanto fine-tune the technology so that it's ready for use nationwide.

Weed management is a key part of the research conducted at the Water Management Research Unit.

"We study how best to ensure high yields with limited water, and critical to managing water is managing weeds. You want a weed-free field for your crop

so there's less competition for available water," Shaner says.

As part of his work with Monsanto, Shaner is growing glyphosate-resistant and glyphosate-susceptible crops and weeds in a greenhouse. He will spray some of those plants with glyphosate and place leaves from others in glyphosate solutions and then determine the levels and rates of shikimate accumulation. The goal is to evaluate different methods for assessing shikimate levels and to determine the most effective way for growers to collect plant material for testing with Monsanto's system. The test kit's design has yet to be determined.

Looking at Other Alternatives

Soybean growers in Georgia have been using the herbicide fomesafen for years, and now with weeds developing glyphosate resistance, cotton growers have been using it as an alternative. It was approved for use on cotton in 2008 after glyphosate-resistant forms of palmer amaranth were discovered in the region. But concerns about potential adverse environmental impacts were noted at the time, particularly its effects on runoff into surface water. Growers also needed more information on how to use it when practicing conservation tillage.

Cotton growers in the region often rotate cotton with peanuts and either conventionally till the soil or use a common conservation practice, strip tillage. When they strip till, they typically use rye as a cover crop, spraying it with an herbicide in March or April to kill it. The dead ryegrass provides a mulch cover for the fields. When herbicides like fomesafen are sprayed, the mulch can intercept the chemical and prevent it from reaching the soil where it will be most effective. Herbicides intercepted by mulch can also damage cotton crops if they wash off after the cotton germinates.

Potter and colleagues evaluated how well a conservation practice known as "irrigation incorporation" would wash the herbicide off the mulch and move it into the soil, reducing the potential for crop injury and excessive runoff. Irrigation incorporation involves irrigating a few days after applying an herbicide. The practice greatly enhances weed control by improving herbicide contact with germinating weeds.

They divided a field of cotton equally between strip tillage and conventional tillage. In the strip tillage section, they planted rye as a cover crop. Fomesafen was applied to the whole field, and irrigation incorporation was used on half of it. They then applied simulated rainfall and diverted runoff into troughs at the lower end of the fields for analysis. The rye crop residue was also collected and analyzed.

The results, published in the *Journal of Agricultural and Food Chemistry* (2011), showed that fomesafen is more likely than other herbicides to wash off surface residue and penetrate into the soil as desired. Fomesafen's "wash-off rate" was much higher than that of other herbicides studied. The results demonstrated the benefits of using irrigation incorporation with fomesafen, particularly when conservation tillage is practiced. The product's high wash-off rate means that by applying a small amount of irrigation after the herbicide is applied, most of it will move into the soil, where it will not damage the cotton and will be most effective at controlling weeds. The results also showed that irrigation incorporation substantially reduces runoff of fomesafen and minimizes the potential for adverse water-quality impacts.

The results will help growers concerned about glyphosate resistance make better-informed decisions about herbicide alternatives.—By **Dennis O'Brien,** ARS.

This research is part of Water Availability and Watershed Management, an ARS national program (#211) described at www.nps.ars.usda.gov.

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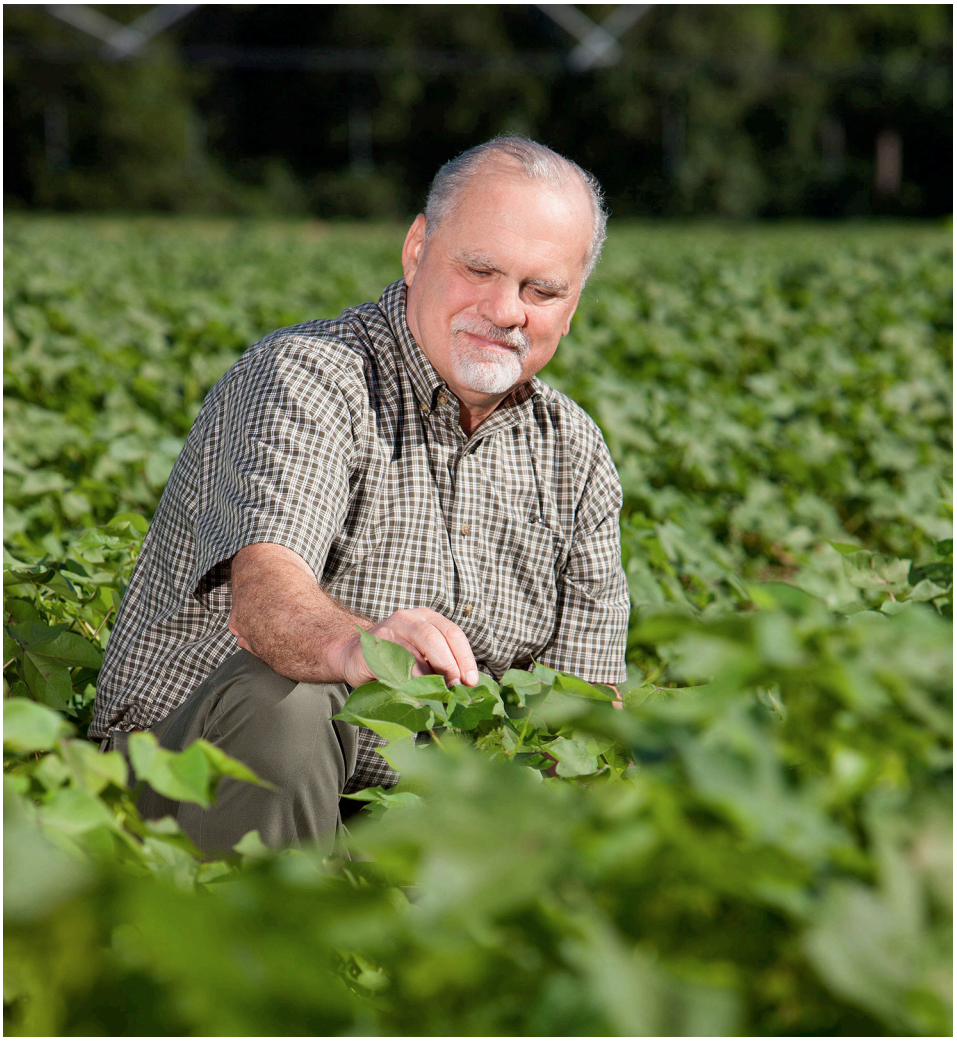

Environmental chemist Thomas Potter examines cotton plants in an herbicide-treated field in Tifton, Georgia. He is studying how different herbicides behave when used with conservation tillage to determine the best combination for cotton farmers.

PEGGY GREB (D2957-2)