The Growing Threat of Pests Resistant to Pesticides and Other Management Tactics

Ongoing Investment in Integrated Pest Management Safeguards America's Agricultural Industry and Food Supply

Executive Summary

Agricultural Pests Constantly Evolve to Resist Pesticides and Other Management Methods

Agricultural pests, including insects, plant diseases and weeds, can become resistant to pesticides and other pest-management strategies. This costs growers money and threatens America's food supply. Climate change is increasing the development of resistant pests. The science of integrated pest management helps prevent resistant pests from emerging and helps manage the ones we're already battling. However, research efforts must keep up with the threats, which can emerge every year.

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Evolution at Work: How Resistance Develops

Most of us are familiar with the dangers of antibiotic-resistant bacteria. Resistant bacteria can develop when someone uses the same antibiotic repeatedly, doesn't take the full course of antibiotics or uses antibiotics when there is no active infection. Those actions give some bacteria a chance to survive and pass that resistance to the next generation, creating antibiotic-resistant bacteria or so-called "superbugs."

The same happens in farming to the pests that growers manage with pesticides and other tactics. Weeds are a good example. They're pests because they compete with crops for light, water and nutrients and can reduce crop yields. Herbicides are a useful way to manage weeds, but occasionally an individual weed will have a genetic mutation that allows it to survive despite being sprayed. When that weed produces seed, it passes on that successful mutation within those seeds. What starts as one herbicide-resistant weed becomes a cluster of them. These then produce more resistant weeds which produce more resistant weeds, year after year, all safe from that herbicide. Soon, growers must try to manage an entire resistant weed population.

In addition to weeds, crops are also vulnerable to insects and diseases. Farmers must manage these pests when they threaten their crops and yields. But if growers repeatedly use the same tool or strategy, all these pests can develop resistance and the tools farmers rely on can stop working.

Resistant Pests Hurt U.S. Agriculture

Farmers spent an estimated $9 billion on pesticides in 2019 in the United States (Mordor Intelligence, 2020). An estimated 10 percent of this cost – some $900 million – was just to respray fields where pests survived a first pesticide application ("Humans as the World's Greatest Evolutionary Force," 2001). Weather and application timing can contribute to pest survival, but pesticide resistance does as well.

And despite that $9 billion spent on pesticides annually, U.S. farmers still lose some 10 to 35 percent of their crops to pest damage. That's a huge financial loss for individuals and the agriculture industry, and also represents millions of tons of food that doesn't make it to our supermarkets and dinner tables. In a time when childhood hunger and food-insecurity are all too common, this is a problem that cannot be ignored.

The biggest danger with resistance is that a pest – an insect, weed or disease – becomes essentially uncontrollable and threatens entire types of crops or farming regions. As our climate changes this danger increases. With longer, hotter growing seasons, farmers are already seeing extra generations of insects to manage before harvest or increased incidence of diseases. This can result in more pesticide applications which can lead to resistance developing even faster.

Science has a Solution – It's Known as IPM or Integrated Pest Management

The science of integrated pest management, also known as IPM, can prevent resistant pest populations from emerging. As the name implies, integrated pest management integrates a variety of strategies and tactics across multiple seasons to protect crops. Because a number of different strategies and technologies are alternated and combined, no individual control method is overused and pests don't become resistant.

Growers trained in IPM plant crop varieties that have been bred to resist common diseases rather than repeatedly spraying fungicides. They conserve beneficial insects on their land to help manage the pest insects that damage their crops. They rotate crops, clean equipment between fields, use mating-disruption products to keep pest numbers down and use selective, low-risk pesticides in rotation when necessary. They make dozens of interlinked decisions throughout the year to economically prevent or control insects, weeds and diseases on their farms or ranches. These strategies are developed and tested by public scientists at America's land-grant universities who research ways to manage specific pests in specific crops and areas. New strategies are then delivered to growers by Cooperative Extension experts across the country.

But pest pressures change. Pests move into new areas as the climate shifts. New crop types are planted, old pesticides leave the market and new technologies are developed. That's why IPM science is never finished and ongoing research and outreach by the IPM specialists at our universities and agriculture research stations will always be needed.

Pesticides and Modes of Action

While pesticides – a collective term for herbicides, insecticides and fungicides – are often used to combat weeds, insects and diseases, they are some of the most temporary and fragile tools unless they are rotated with other management options to avoid the development of resistance.

Pesticides work different ways to kill a pest. These ways are called modes of action and it is a good practice to alternate modes of action between sprays and seasons because pests that survive one control method are often vulnerable to another. To help growers know what mode of action a product uses, an industry-organized group known as the Herbicide Resistance Action Committee created a mode-of-action classification map for herbicide products. If products have different numbers, they have different modes of action. (Herbicide Resistance Action Committee 2020). There are similar resources for insecticides and fungicides as well. Rotating modes of action is one IPM tactic growers use to manage pests and resistance.

IPM helps Prevent Resistance and Manage Existing Resistant Pest Populations

Effective IPM programs help prevent the development of resistance, but there are already a number of resistant insects, weeds and diseases growers must manage. Integrated pest management is the best way – and in many cases the only effective way – to manage these pests. But new resistant populations or the arrival of new invasive pests can disrupt an IPM program and leave growers, and our food supply, vulnerable. As pests develop resistance, there is a consistent need to adapt and improve our IPM programs. Here are some examples of resistant pest populations being effectively managed by IPM tactics.

Insects

Soybean aphids (*Aphis glycines*) have "become the most economically damaging insect of soybean in the Upper Midwest of the United States," with populations resistant to common insecticides in Iowa, North Dakota, South Dakota and Manitoba (Koch et al. 2018).

The IPM approach scientists developed to manage soybean aphids included breeding and planting new soybean varieties that resist the aphids (Neupane et al. 2019) and promoting biological control by preserving their natural predators. By using selective insecticides that only target the aphids, growers can control those insects without harming the multicolored Asian lady beetles that prey on the aphids (Kraiss and Cullen 2008). In addition, other scientists are developing tools that can identify resistant aphid populations quickly, which saves growers from using ineffective pest controls that further promote resistance (Chandrasena et al. 2011; Valmorbida et al. 2019).

Weeds

Waterhemp (*Amaranthus tuberculatus)* is a particularly difficult weed for row-crop farmers to manage. It grows faster and produces more seeds than most weeds – from a quarter-million to a half-million seeds per plant (Tranel 2011; Bradley and Bisch 2018).

Waterhemp populations resistant to the herbicide glyphosate, commonly known as Roundup, were discovered in the early 2000s and as a result growers began increasing herbicide application rates, using herbicides multiple times in a season and mixing different herbicides together to increase effectiveness. Despite these efforts, today there are waterhemp populations resistant to six different modes of action (Bradley and Bisch 2018). Essentially, these plants are capable of surviving six different fatal herbicide attacks at once.

The best management strategy for waterhemp currently is an IPM approach developed by weed scientists. It includes planting with narrow row spacing, using cover crops to suppress the weed populations, and careful herbicide selection to make use of multiple modes of actions. Control of this weed is so difficult that researchers are evaluating a return to more-frequent tillage as a potential control tactic, even though tillage can have detrimental effects on water quality, soil erosion and productivity (Bradley and Bisch 2018).

Diseases

Late blight in potatoes is caused by a pathogen called *Phytophthora infestans,* which also causes tomato leaf blight (Johnson et al. 2016). This disease can infect and kill stems and leaves of potato and tomato plants. Under moderate temperatures and wet conditions, this blight reproduces and spreads rapidly and can quickly destroy an entire season's crop. It was easily managed with a common fungicide, but in the mid-1990s developed resistance.

Managing late blight now is possible with a year-round IPM program to keep the pathogen out of growers' fields and stamp out outbreaks quickly. The program begins with growers selecting seed potatoes that are tested and certified to be disease-free and selecting varieties that are resistant to the infection. In the field, growers create a hill around their plants to prevent potato tubers from poking out above the ground, where they are vulnerable to infection (Fry 1998). Growers monitor weather-based disease forecasts and scout their fields, especially during wet weather. When conditions favor the disease, they apply fungicides to prevent infection, and rotate among products with different modes of action during the season. When they do find an outbreak, they must treat it quickly – within 24 to 48 hours to be effective – otherwise infected plants must be destroyed to avoid spread. At the end of the season, growers must destroy all infected plant parts, including any plants that regrow (Fry 1998).

Looking to the Future

Managing pest resistance will be an ongoing priority for American agriculture, and ongoing funding for crop-protection efforts is essential. New research creates technology to identify and track resistance, develops management tools for newly resistant pests and identifies practices that decrease pest damage, such as row spacing or planting timing. In addition, funding is necessary to support Cooperative Extension services that share this new information with farmers and ranchers to help them implement the IPM programs necessary to slow resistance development, control damaging pests and keep farming. Our rural economies and nation's food supply depend on it.

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The National Integrated Pest Management Coordinating Committee is a committee of the Experiment Station Committee on Organization and Policy and the Extension Committee on Organization and Policy within the Association of Public and Land-grant Universities governing structure. It assists in development of reports and strategic plans on pest management issues and pursues activities that facilitate coordination and collaboration nationally among and between IPM research and extension at the land-grant universities, and between the land-grants and federal agencies involved in IPM.

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