GROWING KNOWLEDGE

Series content is coordinated by Dr. Jay Pscheidt, professor of botany and plant pathology at Oregon State University in Corvallis, Oregon.

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Fighting the resistance

Weeds can become herbicide-resistant, but there are strategies to counteract it

BY LLOYD L. NACKLEY AND MARCELO MORETTI

EVIDENTLY WE HATE WEEDS. The US Environmental Protection Agency (EPA) reports that expenditures on herbicides consistently accounted for the largest portion of total world pesticide expenditures at approximately 45 percent, followed by insecticides, fungicides, and other pesticides.

Amazingly, in 2012, U.S. expenditures accounted for 21 percent of world expenditures on herbicides. It's not only costly, we use a lot too. U.S. pesticide usage totaled over 1.1 billion pounds annually in both 2011 and 2012, with herbicides accounting for nearly 50 percent and 60 percent of total U.S. pesticide usage in 2011 and 2012, respectively.

If you are interested in the details, the pesticide industry sales and usage report are publically available on the EPA website (www.epa.gov/pesticides).

Statistics would suggest that the high proportion of herbicide use is not an indication that there is greater control of weeds. In fact, herbicide use has increased over time, suggesting that we have treated more acreage, and done so more frequently, every season.

It may be the result of labor shortages in the agriculture industry. The current worldwide herbicide market is 50 percent greater than it was 15 years ago. As a result of this heavy reliance on herbicides as a weed management tool, the weeds have become more resistant.

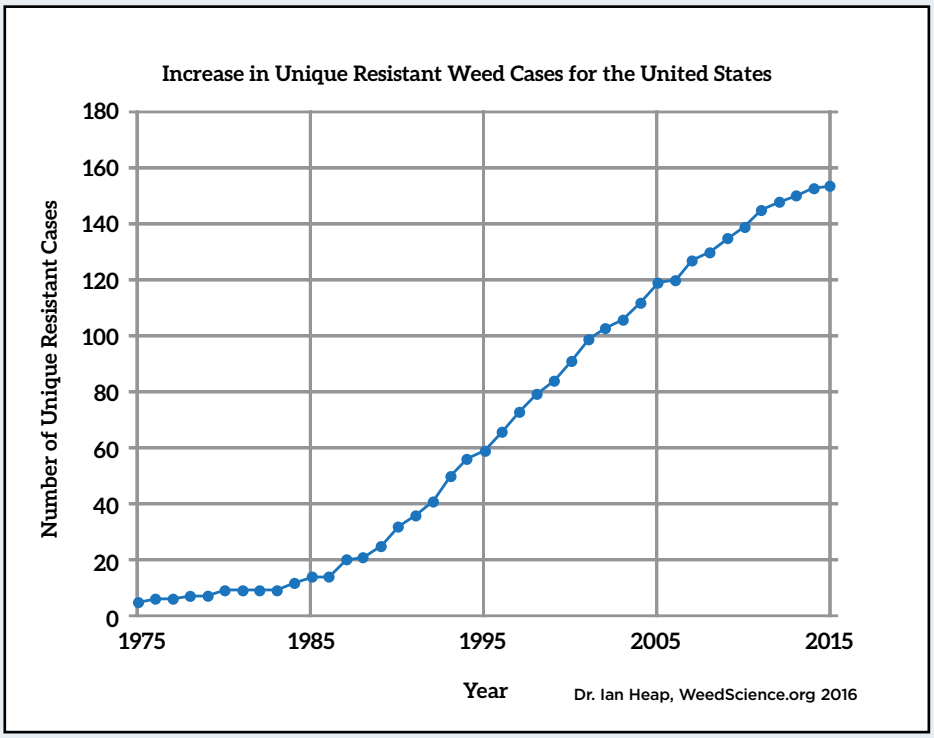

Figure 1: Reported cases of resistance are growing. The International Survey of Herbicide Resistant Weeds (www.weedscience.org), a collaborative effort between weed scientists in over 80 countries, reports that there are currently 482 unique cases (species x site of action) of herbicide resistant weeds globally, with 252 species (146 dicots and 106 monocots). Weeds have evolved resistance to 23 of the 26 known herbicide sites of action and to 163 different herbicides. Herbicide resistant weeds have been reported in 92 crops in 69 countries.

La Résistance

When herbicides are applied to a nursery, greenhouse, or home, the goal is to eliminate susceptible weeds before they reproduce. The repeated use of the same herbicide — or even different herbicides with the same mode of action (MOA) — will favor the survival, reproduction and eventual dominance of resistant plants.

Resistance develops when rare individuals within a traditionally susceptible population survive the application and transmit the resistant traits to their offspring. The inherited traits allow resistant individuals to survive and reproduce despite having received doses of chemicals that are normally lethal (Figure 2, next page).

In some cases, weeds are resistant due to the combination of target-site and non-target site resistance. To further »

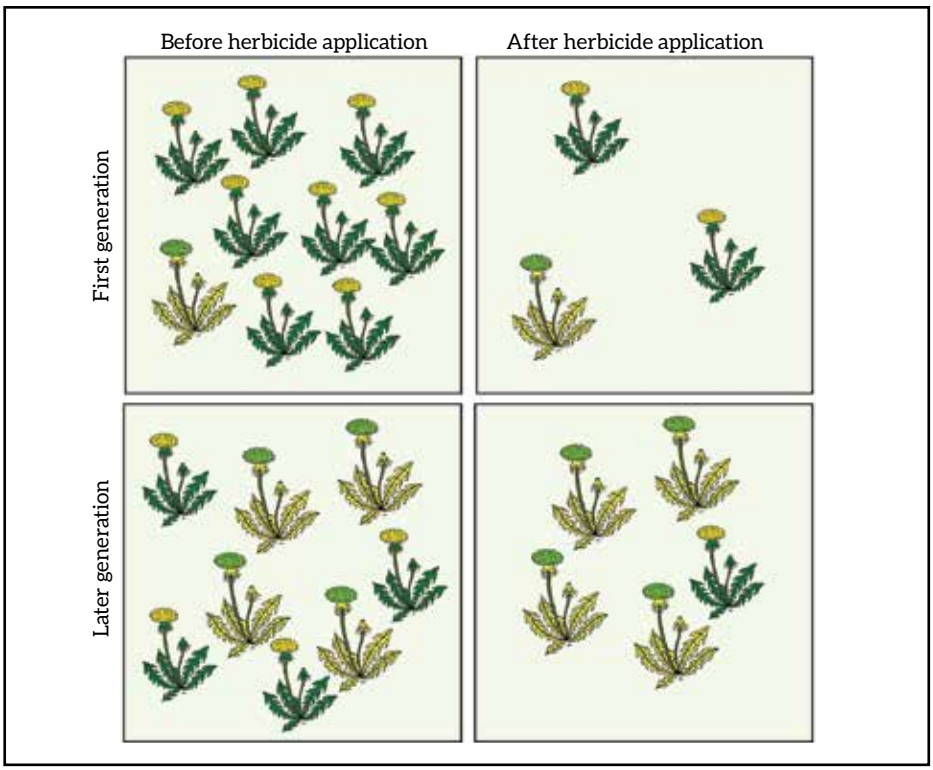

Figure 2: The genesis of resistance is classified in "target site" or "non-target site" mechanisms. Without getting lost in the weeds, target site resistance is endowed by gene mutations in target enzymes. Target site resistance occurs when the specific site (i.e., target) is altered, and the herbicide no longer binds to the site of action and is unable to exert its phytotoxic effect. Non-target site resistance occurs when mechanisms, such as reduced uptake or increased vacuole sequestration, diminish the herbicide concentration reaching the target site.

complicate the scenario, weeds can evolve resistance to several herbicides, which is called multiple resistance. One such example of multiple resistance is an Italian ryegrass population resistant to glyphosate (Round-up, Glystar) and glufosinate (Rely 280, Reckon) that was documented in Oregon orchards, and verified with lab work by Dr. Carol Mallory-Smith.

Resisting resistance

Although weeds make the bulk of expense and chemicals applied to production systems, there is relatively less information about their control compared with insect pests.

For example, a 2015 review of integrated pest management and weed management in the United States and Canada found that there were only five paragraphs specifically dedicated to IPM and weeds in the foundational 120-page publication Integrated Pest Management (DOI: 10.1002/ps.3928).

It has been suggested that a challenge for managing weeds, compared with insects, is the greater similarities between weeds and crops.

Weed science has been growing as a discipline over the years. At Oregon State University we have recently hired Dr. Marcelo Moretti.

Dr. Moretti previously studied glyphosate and paraquat resistance in orchard production systems in California. His research on resistance focused on the distribution, mechanism, and management of multiple herbicide resistant *Conyza* spp. At Oregon State University, Dr. Moretti is developing a program focused on developing strategies for the effective and economical management of weeds for perennial horticultural crops, including ornamental plants. He is also a liaison for minor crop registration program focused on herbicides and biopesticides.

How to manage resistance

In 2012, the Weed Science of America published a list of best management practices for reducing the risks of herbicide resistance. (DOI: 10.1614/WS-D-11-00155.1).

1. Understand the biology of the weeds present.
2. Use a diversified approach toward weed management that is focused on preventing weed seed production and reducing the number of weed seeds in the soil seed bank.
3. Plant into weed-free fields and then keep those fields as weed free as possible.
4. Plant weed-free crop seed.
5. Scout fields routinely.
6. Use multiple herbicide mechanisms of action (MOAs) that are effective against the most troublesome weeds or those most prone to herbicide resistance.
7. Apply the labeled herbicide rate at recommended weed sizes.
8. Emphasize cultural practices that suppress weeds by using crop competitiveness.
9. Use mechanical and biological management practices where appropriate.
10. Prevent field-to-field and within-field movement of weed seed or vegetative propagules.
11. Manage weed seed at harvest and after harvest to prevent a buildup of the weed seed bank.
12. Prevent an influx of weeds into the field by managing field borders.

The BMPs emphasize that it is critical to diversify weed management practices and use multiple herbicide MOAs. Herbicide applicators may not realize that of new herbicide chemistries is rare, that the existing herbicide resource is exhaustible. Indiscriminate herbicide use is leading

to rapid evolution of resistant weeds and could result in the loss of herbicide options.

Labor shortages one of the greatest threats to horticultural production systems. Chemical herbicides are first and foremost a laboring saving mechanism. Efficient, low-cost methods for weed control will remain relevant without an abundant supply of labor.

Popular science suggests that robot weeders may be the answer. Europe has seen success with robotic weeding of row crops, so there may be applicability for field nurseries. Perhaps more immediately, the USDA inter-regional research project no. 4, commonly known as IR-4, assists growers of specialty crops in obtaining safe and effective pest management tools to control weeds as well as other pests and pathogens commonly found in commercial operations.

In the past two years alone, the IR-4 Ornamentals project has coordinated more than 450 herbicide trials by researchers across the country. Dr. Nackley is a research leader for the IR-4 Ornamentals program at Oregon State University. Data and information from greenhouse and field trials that are conducted at NWREC and around the country enable pesticide registrants to add certain ornamental crops to their commercial pesticide labels, providing growers with new and efficient management options. Research activates start with growers, landscape care professionals, researchers or extension agents identifying a need.

Suggestions from commercial growers who have identified an on-farm problem are always welcome and can be directed to Dr. Nackley or Dr. Moretti.

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