How Weeds Develop Herbicide Resistance

Part One of Chemical-resistant Weeds

by Meryl Rygg McKenna

Herbicides have allowed producers to control weeds and increase yields for decades, yet some weeds are no longer killed by certain herbicides due to the development of herbicide resistance.

Herbicide resistance is defined as the innate ability of a weed "biotype" to survive and reproduce after treatment with a dose of herbicide that would normally be lethal. A biotype is a group of plants, animals, or microbes having the same basic constitution in terms of genetic or hereditary factors.

At least seven weed species in Montana have been confirmed for resistance to one or more groups of herbicides: kochia, wild oat, Persian darnel, downy brome, Russian thistle, horseweed and green foxtail.

Chuck Gatzemeier, a Certified Crop Adviser (CCA) in Cut Bank, MT, described the process of plants developing herbicide resistance in this way: When any particular herbicide is applied to a weed population in a field, suppose 99 plants die and one survives. That plant survives because it has something a little different from the others — some basic genetic variation that makes it more resistant to that herbicide. Imagine one in 100 plants, or fewer, because herbicide resistance is rare.

Plants' variability arises from mutations in their genetic makeup. Genetic mutations happen naturally over time, affecting the plant's chances of survival and also altering the biotype.

The plant that survived the herbicide grows and goes to seed. The seeds blow across the field, sprout the following year and survive another application of the herbicide. The second-year seeds are scattered and thus the number of resistant plants grows each year, immune to the same herbicide.

The higher the potential for the weed to reproduce, the more likely it is that the rare resistance gene is passed on, added Prashant Jha, Associate Professor of Weed Science based at Montana State University's Southern Agricultural Research Center in Huntley.

If you apply the same chemical or mode of action to plants that have already survived it, you are creating selection pressure; you are supporting an increased chance of resistant plants.

Chemical modes of action and group numbers

Each herbicide has at least one mode of action — the way it kills a plant. Some affect protein synthesis, acting at certain stages of growth or target sites. A target site is the gene or enzyme where the herbicide binds and affects a plant's growth.

Other herbicides are growth regulators, such as 2,4-D and dicamba, which bring about excessive cell expansion, creating odd tissue formation, twisting and curling, and causing the plant to die.

"People may associate a product's name with its mode of action, but they are not the same thing," Gatzemeier cautioned. "Farmers need to know an herbicide's mode of action to avoid falling for advertisements that say, 'Use this product, it's different,' when it actually uses the same mode of action or active ingredient; it just has a different name."

Modes of action have group numbers. When manufacturers know how a product actually kills a plant, that tells them what group to put it in.

Newer containers of herbicides show the group numbers right on the label. If the label is marked with just one group number, "Group 2" for example, the product uses one mode of action. If you see more numbers separated by commas, such as "Group 4, 7," more than one mode of action is involved.

Charts of the groups are available, showing how they work. Most importantly, remember to use more than one group number, make sure that all the chosen groups are labeled as effective on the target weed, and carefully follow all instructions on the labels.

Manufacturers and distributors have used group numbers for modes of action for quite a while, Gatzemeier said, but understanding them is so much more critical now that plants have developed resistance. Farmers and ranchers can learn more about modes of action and their group numbers by going to University Extension meetings and workshops, reading articles, and connecting with other producers.

It is in the best interests of the customer and agriculture as a whole to understand the labeling system for mode of action groups. Make use of multiple sources of information regarding chemicals. Gatzemeier's advice is to visit with other producers and try to help everyone be aware of the growing problem of resistance.

Resistance in a nutshell

Three basic factors control development of resistant weeds:

1. Selection pressure. If you're using the same product (or its mode of action) over and over, you are selecting for that resistant biotype to take over. One plant didn't die, so its offspring can be resistant. In year two, maybe you have 20 resistant plants, and in year three maybe several hundred.

2. Weed biology. This brings us back to genetic variability in the biotype. Cross-pollination can happen between biotypes in the field, leading to changes in the biotype. The plants are doing this naturally; the process has nothing to do with the herbicide itself.

3. The genetics of resistance. Differences among the various herbicide target sites can dictate whether resistance is more or less likely to develop. Some target sites can develop resistance sooner than others — some take two or three years; some take 20 years or longer.

Over time, a target site can develop resistance through continuous exposure to the same product. Where certain modes of action target particular places on plants, the plants can evolve to counter the herbicide's effectiveness. In some cases, plants can reduce how much herbicide they absorb, reduce the distance the herbicide can move inside a plant, or break down the herbicide to reduce its effects.

Strategies to prevent or manage herbicide-resistant weeds will be discussed in Part Two of this topic.

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