Glyphosate Resistance Prompts Integrated Management

By Stevan Knezevic

Repeated use of the same herbicide is the main reason for weed resistance to herbicides worldwide. The widespread use of glyphosate-tolerant crops and repeated use of glyphosate herbicide is slowly resulting in glyphosate resistance and shifts in weed species.

Weed resistance to herbicides is not a new thing. It began to occur as man started using chemicals for weed control. There is well-documented literature about weed resistance suggesting that at least 44 weed species have been reported to have biotypes resistant to one or more of 15 herbicides or herbicide families. Repeated use of the same herbicide is the main reason for weed resistance to herbicides worldwide.

The widespread use of glyphosate-tolerant crops and repeated use of glyphosate herbicide resulted in many practical concerns due to single-selection pressure on weed populations, which is already resulting in glyphosate resistance and shifts in weed species. In addition, widespread use of glyphosate-tolerant crops results in uncontrolled movement of pollen containing a herbicide-resistant gene, also known as a gene escape.

Glyphosate resistance

Prior to introduction of glyphosate-tolerant crops, there were only a few weed species known to develop resistance to glyphosate worldwide, including rigid ryegrass (*Lolium rigidum*) in Australia (Powels, 1998) and California and goosegrass (*Eleusine indica*) in Malaysia. However, the number of glyphosate resistant weeds tripled in about eight years of repeated glyphosate use over a much larger land area (more than 100 million acres).

Current examples of glyphosate-resistant weeds in the United States include: waterhemp (*Amaranthus rubis*, Sauer), lambsquarters (*Chenopodium album*), marestail (horseweed) (*Conyza canadensis*)(Davis et al. 2006), giant ragweed (*Ambrosia trifida*), common ragweed (*Ambrosia artemisiifolia*) (Smeda R. 2006), and palmer amaranth (*Amaranthus palmeri*). These weeds are found in various parts of Midwestern and Southern states.

There are marestail populations with various levels of resistance to glyphosate in at least eight states. The objective of this study is to develop dose response curves for glyphosate on five marestail populations and compare their resistance levels.

Seeds of five marestail populations were collected last fall in Nebraska and Indiana, greenhouse bioassays conducted last summer, and dose response curves for glyphosate defined for each marestail population. Curve comparisons clearly showed a glyphosate resistance level ranging from three times to six times depending on the population. For example, 90 percent control of a susceptible population was achieved with 32 ounces of glyphosate (3 pounds per gallon acid equivalent, at one-times rate), while the resistant populations needed about 100 ounces/acre (three-times rate) and 200 ounces (6-times rate) in order to achieve the same level of control.

Weed shifts

Weedy and invasive species can adapt easily to changes in the crop or turf system management in order to take advantage of the available niche (Mooney and Cleland, 2001).

Species that do not adapt to management changes become "less frequent" compared to those that do adapt. Therefore, despite the fact that glyphosate controls many weed species, it does not control all plant species (Franz et al., 1997). Certain weed species can survive in crop or turfgrass systems based on glyphosate-tolerant crops because of their natural tolerance to glyphosate, and/or because of growth types or life cycles that help them avoid being treated (Madsen and Streibig, 2000).

As a result of repeated use of glyphosate in Nebraska, there is a slow shift in weed species occurring from three stand points: 1) from glyphosate-susceptible to glyphosate-resistant populations, 2) from weeds easily controlled by glyphosate to those with natural tolerance to the current label rate of this herbicide, and 3) to those weed species that have growth types, or life cycles, that helped them avoid being treated by glyphosate, such as an increase in winter annual weed species (Knezevic S, 2006).

Knezevic and Klein (2005, 2006) compiled a list of problematic weed species in field crops, which included: wild buckwheat (*Polygonum convolvulus*), Pennsylvania smartweed (*P. pensilvanicum*), lady's thumb (*P. lapathifolium*), ivyleaf morning glory (*Ipomea hederacea*), venice mallow (*Hibiscus trionum*), horseweed (*Conyza canadensis*), yellow sweet clover (*Melilotus officinalis*), and field bindweed (*Convolvulus arvensis*).

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If the trends in weed shifts continue to occur, glyphosate used alone will no longer be a viable tool for weed control in the systems based on glyphosate-tolerant crops.

Mixing glyphosate with other post-emergence broadleaf herbicides or using soil-applied herbicides after crop planting will be needed to control these species effectively. But it will increase the overall cost of weed control because the producers have to pay for both the technology fee and additional herbicides (Knezevic and Klein, 2006).

An increase in occurrence of winter annual weeds was also reported for cropping systems based on glyphosate-tolerant crops in Nebraska (Knezevic S. 2006). It is believed that the overall increase in winter annual species is likely the result of reduced use of pre-emergent herbicides, and/or those post-herbicides that have residual activity in glyphosate-tolerant crops (Knezevic S, 2006). The list of commonly found winter annuals includes: field pennycress (*Thlaspi arvense L.*), shepherds purse (*Capsella bursa-pastoris*), henbit (*Lamium amplexicaule*), and tansy mustard (*Descurainia pinnata* Walt. Britt).

These species are becoming a common scene during late fall (October, November) and early spring (March-April) throughout eastern Nebraska and western Iowa. Designing management strategies for winter annuals is needed, but it will increase the overall cost of weed control.

Gene escape

The potential for "gene escape" conferring herbicide resistance via pollen from glyphosate-resistant crops to other plant species is another major concern, especially from crops closely related to wild relatives (Zemetra et al. 1998). A herbicide-resistance gene was naturally transferred via pollen from herbicide-tolerant IMI-wheat to jointed goatgrass (*Aegilops cylindrica*) in the northwestern United States (Seefeldt et al., 1998). Others also have reported that pollen flow was the main reason for naturally occurring multiple resistance of canola (*Brassica napus*) to three commonly used herbicides (glyphosate, glufosinate and imazethapyr) in Alberta, Canada (Hall et al., 2000).

The probability of gene escape increases if the plant species are closely related (e.g. same genus) because of the possibility of cross pollination (Harlan, 1982). The list of so called "high risk crops" and their weedy relatives includes: sorghum and its weedy relatives shattercane and johnsongrass; canola and mustards; wheat with jointed goat-grass and quackgrass; rice and red rice; sunflower and wild sunflower; and various grassy species (turfgrasses).

Proper use of herbicide-tolerant technology, as a component of an integrated weed-management program, is the key for getting the most benefits out of this technology while avoiding many of the concerns about their use or misuse.

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