Herbicide Failures & Resistance

Related to Christmas Tree Production

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Herbicide resistance in weeds means the inherited ability of a plant or population to survive exposure to an herbicide that was previously known to kill that species. Resistance is a change that occurs over time and is not caused by the herbicide mutating or actively altering the weeds, but rather by selection pressure or the introduction of new weed genetics (i.e. seeds or other propagules). This contrasts herbicide tolerance, where an herbicide also does not kill a plant species, but in this case this chemical has never been effective. As an example, the herbicide 2,4-D, a Group 4 synthetic auxin, selectively controls broadleaf species; it has never been effective in controlling grasses like quackgrass. Quackgrass is therefore considered tolerant to 2,4-D.

FIGURE 1

The Weed Science Society of America states that nine out of ten herbicide failures are related to factors other than resistance. Before assuming an individual weed or weed population (several individuals in the same location) is resistant, other considerations should be made such as:

Environmental conditions

- Coverage can be influenced by time of day as leaf angles change, which in turn impacts absorption.
- Stress caused by weather extremes, such as drought or excess precipitation can impact uptake and efficacy of herbicides in weeds.
- Cloud cover can impact efficacy of some products.
- Soil-applied herbicides can be affected by too much or too little precipitation.

Application errors

- Labeled rates for the crop and weed species of interest need to be followed to maximize effectiveness.
- Following the application timing listed on the herbicide label is important to achieve effective weed control.
- Spray equipment factors such as clogged, worn, or inappropriate nozzles, worn pumps, appropriate boom height, etc. need to be considered, and application equipment should be calibrated with changes in product formulations and a minimum of once per calendar year.
- Non-labeled tank mix partners, hard water, and pH imbalance can create issues that make herbicides less effective than expected.

Weed status and density

- Correctly identifying the weeds present and selecting an herbicide labeled for control of those species in Christmas trees are both important factors.
- Many preemergence herbicides are not effective on weeds after they have already emerged. Likewise, some postemergence herbicides do not have activity on weeds beginning to germinate from seed and may not have residual activity in the soil.
- Weeds are usually most sensitive to postemergence herbicides during the early vegetative stages. Once weeds are too tall or begin to reproduce, some postemergence herbicides can be less effective.
- Well established perennial weeds may require repeated applications of herbicides to completely exhaust their rhizome (if present) and root systems.
- If the vegetation is dense within the field (weeds and/or crop) it can create a shading effect and reduce exposure to the herbicide applied.

After making these considerations, herbicide resistance may still be suspected. Think about the pattern of surviving weeds and the other vegetation in the field. Was it just this species that survived, while other species were controlled? If there are other weed species that also survived, it is likely one or more of the factors mentioned above that is to blame. If it is just one species, the individuals that were not controlled may appear as a spreading patch or they may appear interspersed amongst individuals of the same species that were successfully controlled (indicating genetic segregation is on-going). Both of these patterns can be ways in which herbicide-resistant weeds first appear. The actual resistant individuals may appear completely unaffected (Figure 1), slightly injured, or stunted. Regardless of their appearance, resistant weeds continue to grow and reproduce, which perpetuates the problem, particularly in annual species (Figure 2).

If resistance is suspected, it is important to get it tested for confirmation.

FIGURE 2

Figure 1. *Fourteen days after a 1x field rate (32 fl oz/A) of Roundup PowerMax® (glyphosate), this Palmer amaranth appears relatively unaffected (left) compared to the untreated control (right), whereas the 4x rate completely controlled this population (middle) (Photo by E. Hill).*

Figure 2. *Though a resistant plant may be injured or stunted by an herbicide, the ability to flower and produce seeds spreads the resistance issue. This turfgrass renovation plot was sprayed with glyphosate and only the marestail survived. Though injured from mowing and the herbicide application, these plants produced flowers even at heights of only 2" (Photo by E. Hill).*

Depending on the weed species and herbicide in question, resistance is either tested by molecular methods or greenhouse bioassays. Molecular methods can produce quick results from plant tissue; however, they are only possible for previously known resistance issues that have been well characterized. Greenhouse bioassays require the collection of seed and may take many months to conduct; however, any weed species and herbicide combination can be tested (Figure 3). The science in this area is rapidly changing, so it would be important to check with local and regional diagnostic clinics to determine what is possible and whether tissue or seed would need to be collected for testing.

Herbicide resistant weeds in Christmas tree production fields have been confirmed thus far as follows. This list includes other species to watch that have been confirmed resistant in other agricultural production systems:

- ALS (acetolactate synthase) inhibitor resistance- Group 2 [e.g. Mission® (flazasulfuron) and Westar® component (sulfometuron)]
  - Common ragweed
  - Marestail/horseweed
  - Species to watch: common lambsquarters, pigweed species, giant ragweed
- Synthetic auxin resistance- Group 4 [e.g. Stinger (clopyralid) and 2,4-D]
  - Common ragweed – clopyralid-resistant only (Figure 4)
  - Species to watch: wild carrot, buckhorn plantain
- Photosystem II inhibitor resistance- Groups 5, 6, & 7 [e.g. atrazine, Princep® (simazine), Velpar® and Westar® component (Hexazinone)]
  - Common lambsquarters
  - Common ragweed
  - Powell amaranth
  - Marestail/horseweed
  - Velvetleaf
  - Species to watch: Common groundsel, common purslane, pigweed species, ladysthumb, eastern black nightshade
- EPSPS (5-enolpyruvalskikimate-3-phosphate synthase) inhibitor resistance- Group 9 [i.e. glyphosate]
  - Marestail/horseweed
  - Species to watch: Palmer amaranth, waterhemp, common ragweed, giant ragweed
- PPO inhibitor resistance- Group 14 [e.g. SureGuard®/BroadStar™/Cobra® (flumioxazin), and GoalTender® (oxyflurofen)]
  - None known in Christmas trees thus far
  - Species to watch: Common ragweed, Palmer amaranth, waterhemp

In addition to the species listed above, there are several cases where weed species have been found to be multiple-resistant, meaning they are resistant to more than one herbicide site of action group. For example, marestail populations in Michigan are often found to be resistant to both the ALS inhibiting herbicides (Group 2) and glyphosate (Group 9). More incidence of herbicide resistance and multiple resistance can be explored in the International Herbicide-Resistance Weed Database (weedscience.org). In Michigan, there is also a county specific map and listing of all confirmed herbicide resistance in weeds available at Michigan State University Plant & Pest Diagnostics (https://www.canr.msu.edu/pestid/resources/plant-and-weed-identification/map).

There are several best management practices that can be utilized to prevent or delay the onset of herbicide resistance in Christmas trees. Following are some of these best management practices:

FIGURE 3

Figure 3. *If a novel case of resistance is found, a dose response experiment is conducted to determine the level of resistance by comparing the resistant population to a known susceptible population at incremental rates of the herbicide. Here common ragweed was treated with Stinger® (clopyralid) The 1x field rate of Stinger® is equal to 5.3 fl oz/A; the 0x plants were not treated (Photo by E. Hill).*

Figure 4. *This population of common ragweed in Michigan was unaffected by a treatment with Stinger® (clopyralid). It was later confirmed as the first reported case of resistance to the Group 4 synthetic auxin herbicides in common ragweed worldwide (Photo by B. Zandstra).*

- Understand the biology of the weeds present
- Use cultural practices that favor crop growth and vigor (e.g. fertilization, pre-plant weed controls, cover crops, irrigation, managing disease and insect pests, etc.)
- Use weed-free inputs (e.g. cover crops, compost)
- Diversify weed management tactics and focus on preventing weed seed production
- Use multiple, effective herbicide modes of action
- Make herbicide applications at labeled rates to appropriately sized weeds
- Clean equipment between fields to prevent spread of known issues
- Scout to look for new issues, with special attention to field borders

FIGURE 4