Waterhemp Resistance to 2,4-D and Other Herbicides

Waterhemp Resistance Tendencies

Waterhemp is a widespread weed species with several traits that make it problematic for agriculture. It has evolved herbicide resistance to more site-of-action groups than any other Midwestern weed species and a single female plant can produce 250,000 to over a million seeds.[1,2] Additionally, cross-pollination from separate male- and female-flowered plants (Figure 1) increases the genetic variability of individuals, which in turn generates an increased frequency of new traits conferring herbicide resistance. Since the early 1990s, waterhemp in the US has been developing resistance to herbicide sites of action (Table 1).

Figure 1. Female waterhemp heads can produce a million seeds. Courtesy of Aaron G. Hager, University of Illinois.

Table 1. Evolution of waterhemp herbicide resistance in the United States.

Year	Site of Action Resistance	Herbicide Group Classification	Active Ingredient Examples*
1993	Inhibition of acetolactate synthase	Group 2	imazethapyr, thifensulfuron-methyl, chlorimuron-ethyl
1994	Photosystem II inhibitors – serine 264 binders	Group 5	atrazine
2001	Inhibition of protoporphyrinogen oxidase	Group 14	lactofen
2006	Inhibition of enolpyruvyl shikimate phosphate synthase	Group 9	glyphosate
2009	Auxin mimics	Group 4	2,4-D; picloram; aminopyralid
2009	Inhibition of hydroxyphenyl pyruvate dioxygenase	Group 27	mesotrione, tembotrione, topramezone
2016	Very-long-chain fatty acid synthesis inhibitors	Group 15	dimethenamid, acetochlor, S-metolachlor, pyroxasulfone

Source: Heap, I. 2024. The International Herbicide-Resistant Weed Database. www.weedscience.org. *not a complete list, based on first-year resistance

Waterhemp Resistance to 2,4-D and Other Herbicides

Resistance Alleles

Different versions of the same gene are called alleles. An individual can inherit different alleles for different versions of the same gene from each of its parents, and these alleles can carry naturally occurring mutations in wild populations of weeds. Various mutant alleles confer herbicide resistance in weeds. As herbicide use is repeated, plants with herbicide-resistant alleles survive more often than plants without herbicide-resistant alleles, and surviving plants may produce seed that carries those same resistant alleles. As more surviving seed is produced by herbicide-resistant plants – and waterhemp generates ample amounts of seed – the frequency of herbicide-resistant alleles increases in a weed population.

Protecting Weed Management Tactics

In the US, a two-way multiple-herbicide-resistant (MHR) waterhemp population was recorded in 1998.[3] Now, more than half of the sampled Missouri waterhemp populations have two-way MHR. In isolated locations, four-, five-, and six-way MHR populations have developed.[3,4] In Iowa, most waterhemp populations are MHR to herbicide groups 2, 5, and 9.[5]

The reduced susceptibility of Iowa waterhemp populations to new herbicide-trait programs is even more concerning. A study published in 2023 found that, on average, waterhemp collected from corn and soybean fields in Iowa survived field-rate applications of a 2,4-D herbicide 17 percent of the time, dicamba 5 percent of the time, and glufosinate 4 percent of the time.[5] There have been reports of 2,4-D resistant waterhemp populations for more than a decade. Some populations in Iowa even have survival rates greater than 50 percent after being treated with 2,4-D herbicide. Furthermore, some of these high-survival populations have resistance to multiple other herbicide sites-of-action.[5] Less susceptibility to 2,4-D means increasing dependence on dicamba and glufosinate, though sole reliance on these herbicides should be avoided to increase their window of effective use.

Increasing herbicide use rate or number of applications to overcome reduced sensitivity is not a sustainable solution to controlling herbicide-resistant weeds. These increases can speed up developing resistance because each herbicide application selects for herbicide-resistant alleles, since herbicide-resistant plants are more likely to survive and produce seed than non-resistant plants whenever herbicides are applied. Herbicide-resistant weeds cannot be allowed to produce seed and farmers can no longer rely on one active ingredient for POST herbicide programs. Multiple cultural practices, mechanical tactics, and herbicide sites of action should be used in diverse combinations to reduce the degree of selection pressure on weeds.

Waterhemp Resistance to 2,4-D and Other Herbicides

Integrated Pest Management

Herbicide options depend on the waterhemp population, crop, and trait plans for each field. Resistance to several herbicides is well-recorded, but weed populations evolve seasonally. Check with local universities to see if waterhemp populations can be tested for resistance to glyphosate and Group 14 herbicides.[4] While multiple effective herbicides layered throughout PRE and POST applications can delay resistance development, herbicide use alone cannot prevent resistance.

Reduced rates of PRE herbicides increase selection pressure on waterhemp. Waterhemp presents resistance to PRE herbicides through reduced duration of control. The control from residual herbicides may be reduced by two days or two weeks depending on the waterhemp population, as herbicide responses can vary between weed populations. For example, some Illinois waterhemp populations are resistant to S-metolachlor while some populations are still sensitive to it.[1] Herbicide failures should be recorded, as this information is imperative to plan integrated pest management.

Figure 2. Limited numbers of effective POST herbicides for waterhemp control in soybeans can lead to escapes and reduced control.

Waterhemp Resistance to 2,4-D and Other Herbicides

To help improve herbicide effectiveness, apply herbicides to waterhemp when the plants are less than three inches tall. Even low-level resistant weeds have increased herbicide susceptibility when they are one inch tall compared to taller growth stages.[6] Early scouting is necessary, as favorable environmental conditions can cause this weed to grow over one inch per day.[7]

Diversify both PRE and POST herbicide programs through tank mixing and rotating multiple effective modes of action. This can be facilitated by choosing different herbicide tolerance traits.

Aggressive tillage possibly kept this weed from becoming an economic problem – even if it was widespread – for most of the 1990s.[2] As soil is inverted, waterhemp seeds become deeply buried. Small-seeded waterhemp usually germinates from the top part of soil, where sunlight easily reaches to initiates germination. Tillage can be combined with herbicide use as a backup to control missed weeds or to clear a field surface prior to PRE herbicide application.

Rouging waterhemp escapes before seed heads develop is critical with the high fecundity potential of female plants. Mowing or electrocuting have been done to eliminate weed escapes if labor is not available to hoe. Any herbicide-surviving plants are carrying herbicide-resistant genes for the next generation of waterhemp. Control of escapes is a major part in taking action against resistant waterhemp.

Cover crops such as cereal rye, wheat, or barley can reduce waterhemp populations up to 50 percent, though seedbanks with extremely high waterhemp pressure (500 or more plants per square meter) may not be good candidates for weed control by a cereal rye cover crop.[4,7] A related practice, mulching with cereal rye residue, has also worked to control waterhemp prior to soybean planting.

Areas with a long history of waterhemp are developing MHR and should be closely monitored for shifts in herbicide effectiveness. Herbicide-resistance management requires weed control before seed head development. Seedbanks overwinter genetics which survived previous control attempts and carry them into next year, and to several years beyond.

[Sources]

[1] Hager, A. 2022. Waterhemp resistance to Group 15 herbicides. Take Action Herbicide-Resistance Management. https://iwilltakeaction.com/wp-content/legacy/uploads/files/61947-3-ta-group15-factsheet-final.pdf

[2]Arana, J. and Meyers, S. 2020. Waterhemp. Purdue University, Article 675. https://vegcropshotline.org/article/waterhemp/

[3]Hamberg, R.C., Yadav, R., Dixon, P.M., Licht, M.A., and Owen, M.D.K. 2023. Monitoring the temporal changes in herbicide-resistant *Amaranthus tuberculatus*: a landscape-scale probability-based estimation in Iowa. Pest Management Science. 79(12): 4819–4827. https://doi.org/10.1002/ps.7682

[4]Loux, M.M. 2020. Problem: waterhemp is becoming resistant to everything. Ohio State University Extension, ANR-78. https://ohioline.osu.edu/factsheet/anr-78#:~:text=Cross%20pollination%20results%20in%20tremendous%20variability%20within%20populations%2C,to%20develop%20resistance%20more%20rapidly-%20than%20most%20weeds.

[5]Hamberg, R.C., Yadav, R., Owen, M.D.K., and Licht, M.A. 2023. Differential susceptibility of Iowa waterhemp (*Amaranthus tuberculatus*) populations to 2,4-D, dicamba, and glufosinate. Canadian Journal of Plant Science. 103(6): 595–599. https://doi.org/10.1139/cjps-2023-0081

[6]Ikley, J. 2023. Herbicide-resistant weeds. North Dakota weed control guide. p. 97. W253-23.

[7]Bish, M. 2021. Study finds cover crops can reduce waterhemp pressure. Missouri Ruralist. https://www.farmprogress.com/weeds/study-finds-cover-crops-can-reduce-waterhemp-pressure

Legal Statements