Managing PPO-Resistant Weeds in Soybeans

Protoporphyrinogen oxidase (PPO) inhibitor herbicides are widely used for postemergence and residual weed control and the management of glyphosate-resistant weeds in soybeans. Tall waterhemp, common ragweed, and Palmer amaranth have evolved as PPO-resistant weeds in many parts of the country.[1] Best management practices are needed to manage resistant weeds and preserve the effectiveness of PPO herbicides for use in soybeans.

PPO Herbicides

PPO inhibitors belong to various chemical families and are classified as group 14 site-of-action herbicides (Table 1). The primary site-of-action of these herbicides is inhibition of the PPO enzyme which leads to the disruption or leaking of cell membranes. These herbicides are effective against broadleaf weeds, but some have activity on grasses. Many are contact-type, postemergence herbicides with limited translocation in plants. Visual symptoms are generally leaves that become chlorotic (yellowing) followed by necrosis (browning) and desiccation within 1 to 3 days. PPO inhibitors that are soil-active generally have short to moderate residual activity lasting about 4 to 6 weeks. These herbicides applied alone or in mixtures with other herbicides are widely used for residual weed control in soybeans. PPO herbicides are also important in soybeans for the management of glyphosate-resistant weeds to include Palmer amaranth and waterhemp.

PPO-Resistant Weeds

Resistance to PPO herbicides has been confirmed in thirteen weed species globally.[1] Three weed species are reported to be PPO-resistant in the United States. Tall waterhemp (*Amaranthus tuberculatus*) was the first weed to evolve PPO-resistance and was reported in Kansas in 2001 (Figure 1).[1] Waterhemp currently has the most widespread resistance to PPO herbicides occurring in the states of KS, NE, MO, IA, IL, IN, MN, and WI. PPO-resistant common ragweed (*Ambrosia artemisiifolia*) was first reported in Delaware in 2005, and is now also occurring in NJ, MD, NC, OH, and MI (Figure 2).[1] PPO-resistant Palmer amaranth (*Amaranthus palmeri*) was first reported in 2011 in Arkansas, and is now also occurring in Tennessee and Illinois (Figure 3).[1] It is believed to be only a matter of time before PPO-resistant Palmer amaranth spreads throughout the South and Midwest. Resistance to PPO herbicides in weedy species has been attributed to mutations in the PPO gene.[2] The intensive use of PPO herbicides can exert high selection pressure leading to the evolution of resistant weed populations within a short period of time. In addition, weed populations with multiple resistance to PPO and ALS inhibitors as well as to glyphosate have evolved.

Table 1. Common names of selected PPO herbicides used in soybeans.

Chemical Family	Active Ingredient	Product Name
Diphenylethers	acifluorfen	Ultra Blazer®
	fomesafen	Reflex®, Flexstar®
	lactofen	Cobra®, Phoenix™
N-phenylphthalimides	flumiclorac	Resource®
	flumioxazin	Valor®
Pyrimidinedione	saflufenacil	Sharpen®
Triazinones	carfentrazone	Aim®
	fluthiacet	Cadet®
	sulfentrazone	Authority®

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Best Management Practices

Best management practices for the control of PPO-resistant weeds involves the use of herbicides along with mechanical and cultural practices.

- **Crop rotation.** In a corn/soybean rotation, proactively manage broadleaf weeds with effective herbicide options available in corn to reduce the soil seed-bank when in soybeans where PPO-resistant weeds can be more difficult to manage.
- **Tillage.** Deep tillage can help on less erosive fields with a history of high weed densities.
- **Cover crops.** Dense cover crop systems can impede spring weed emergence.
- **Narrow rows and increased seeding rates.** Planting soybeans in narrow or drilled rows and at higher seeding rates encourages canopy closure which can suppress weed emergence.
- **Start clean** using a herbicide burndown application or tillage. Using an effective residual herbicide in the burndown application helps to maintain a clean field prior to planting.
- **Scout fields** to determine herbicide burndown or tillage effectiveness. It is also important to scout fields for seedling weeds where preemergence herbicides were applied at planting as soil residual activity of herbicides fade away. Scouting also helps to recognize if weeds might be displaying resistance. A broadleaf weed is susceptible to an applied PPO herbicide if the top leaves burn and fall off. However, it is likely showing resistance if the tops only mottle and the plant continues to grow.
- **Spray early** to kill weeds before they reach 4 inches in height. Smaller weeds are easier to control.
- **Use overlapping residuals** to maintain bare soil and control later germinating weeds. Include postemergence herbicides when necessary to control emerged weeds. Overlapping residual herbicides can help from a resistance management standpoint and provide more flexibility with timely postemergence herbicide applications.
- **Employ multiple sites of action** to reduce selection pressure on any one given herbicide and slow the spread of resistant weeds.
- **Roundup Ready 2 Xtend® Soybeans and the Roundup Ready® Xtend Crop System** allows the use of a low volatile formulation of dicamba for control of tough broadleaves and resistant weeds. The system allows the use of XtendiMax® herbicide with VaporGrip® Technology, a restricted use pesticide, before, at, and after planting of Roundup Ready 2 Xtend soybeans.
- **LibertyLink® Soybeans** allows the use of Liberty® herbicide (glufosinate) as an in-crop application for control of small weeds from emergence up to bloom of LibertyLink soybeans. Liberty is a contact-type herbicide and must be applied when weeds are small (<4 inches) because it does not have the translocation abilities of a herbicide like glyphosate.
- **Hand weeding.** Hand removal of weeds may be necessary to prevent resistant weeds from dropping seed and adding to the soil seed-bank.
- **Clean equipment.** Minimize field-to-field weed seed movement by cleaning of tillage and harvesting equipment.

Using new herbicide trait packages, postemergence and preemergence herbicides, multiple sites-of-action, overlapping residual herbicide applications, and a diversified program that includes cultural practices will help in the management of PPO-resistant weeds and preserve the effectiveness of PPO herbicides for use in soybeans. Continue to monitor weed resistance issues in your fields and manage accordingly.

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Figure 1. Waterhemp seedlings.

Figure 2. Common ragweed in early growth stage.

Figure 3. Top image: Palmer Amaranth seedlings. Bottom image: Young Palmer Amaranth plant

Sources (verified 3/23/20)

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