

MANAGING HERBICIDE-RESISTANT PALMER AMARANTH

Palmer amaranth (pigweed) is the bellwether or index weed for herbicide-resistance. Biotypes that are resistant to numerous Mechanisms/Modes/Sites of Action ([MOA](#)) [have been identified](#). Glyphosate-resistant (GR) Palmer amaranth is of particular concern, and is found throughout the soybean production region of the US.

Palmer pigweed's rapid growth and its aggressive competition make it a formidable weed pest in Midsouth crops. Also, it is an extremely prolific seed producer, and this, along with its germination throughout the growing season, further enhance its place as the most problematic weed in crop production.

GR Palmer amaranth has created a conundrum for producers. Using glyphosate for weed control in GR soybean has been and continues to be a preferred management tool, but the advent of GR weeds such as Palmer amaranth has reduced its utility. So even though glyphosate is still an effective herbicide for weed management in GR soybeans, its use must be on a selective basis and in coordination with other herbicides with different MOA's to either prevent or delay the selection for other GR weeds resulting from its overuse.

This is a problem that must be managed if profitable soybean production is to continue. Control options involving herbicides depend on using

- Older non-glyphosate herbicides,
- Premixes of non-glyphosate herbicides,
- Premixes of non-glyphosate herbicides and glyphosate,
- Liberty herbicide on LibertyLink soybean varieties, and
- Auxin herbicides (dicamba and 2,4-D) on tolerant soybean varieties.

The following compilation of the best management practices for control of herbicide-resistant (HR) pigweed in Roundup Ready, Liberty Link, Xtend, Enlist, and conventional soybean production systems is from the following sources.

- [The University of Georgia](#) by Dr. Eric Prostko;
- [The University of Arkansas](#) by Drs. Scott and Smith;
- [North Carolina State University](#) by Drs. Everman and York;
- [Palmer Amaranth Mgmt., USB Fact Sheet.](#)
- [Palmer Amaranth Mgmt. In Xtend Soybean and Multiple-Resistant Palmer Amaranth](#), Univ. of Tennessee by Dr. Larry Steckel.
- [PPO-Res. Pigweed Mgmt.](#), MCS, by Drs. Bond, Reynolds, and Irby
- [HR Pigweed Mgmt.](#), MCS, by Dr. Bond, Irby, and Reynolds

It is likely that the above USB resource will be updated regularly; thus, it may be the most appropriate up-to-date source of information for this constantly evolving issue.

Also, the [MCS](#), [Ark. Row Crops](#), and [UTCrops.com](#) blog sites should be checked regularly for updates regarding this constantly evolving situation with Palmer Amaranth.

From the above sources and the below table, the following tenets apply to management systems for control of GR pigweed.

- **Rotate herbicide chemistry as much as possible.** Use the Group numbers shown on herbicide labels to determine the [MOA](#) of the listed herbicides and premixes. Rotation of varieties that are tolerant to glyphosate, Liberty, dicamba, 2,4-D, and conventional herbicides will delay the onset of HR weeds if not already present, or will help manage

- populations of HR weeds that are present.
- **Rotate crops where possible.** Including corn in a crop rotation with soybeans is an advantage since an atrazine (MOA Group 5)-based weed control program used for corn is an effective tool for controlling pigweed.
- **A residual herbicide** should be part of any weed management program for HR pigweed in all herbicide-tolerance trait systems—e.g. Roundup Ready, Liberty Link, Xtend, Enlist, and Conventional soybeans. This reduces the pressure on POST-only management.
- Herbicide combinations such as Authority XL, Authority MTZ, Boundary, Canopy, Envive, Prefix, and Valor XLT that contain at least two MOAs provide the most consistent and effective control of pigweed.
- POST options in the below table—Flexstar, Flexstar GT, Prefix, Pursuit, Sequence, and Warrant—have residual activity on Palmer amaranth, and their use will enhance in-season control of pigweed.
- Palmer amaranth should be treated with POST herbicides when the weed is no taller than 3 in.
- Midsouth growers should assume that all Palmer pigweed is now resistant to glyphosate and react accordingly in planning a herbicide weed control program.
- POST applications of herbicide mixes that include glyphosate should be applied to weeds at the recommended time/size for the non-glyphosate herbicide in the mix since that is the component that will control the GR weed.
- Contact POST herbicides such as Cobra, Flexstar, Flexstar GT, Liberty, and Prefix that are applied to kill pigweed should be applied using flat-fan or twin-jet nozzles and a spray volume of at least 15 gal./acre to ensure adequate spray coverage.
- Management tenets for control of pigweed in LibertyLink soybean varieties are basically the same as those for Roundup Ready soybeans with the following exceptions: Liberty herbicide is used instead of glyphosate.
- Soybean yield and control of pigweed resulting from use of recommended POST applications of Liberty alone on LibertyLink soybean varieties were as good as those resulting from the use of preemergence (PRE) residual herbicide applications followed by recommended POST applications of Liberty. See next item for resistance management caveat.
- **Do not overuse Liberty since this will increase selection pressure for resistance to this herbicide;** i.e., do not depend entirely on Liberty for weed control. Do not exceed two applications of Liberty per year, do not use reduced rates, and treat weeds when they are small. Apply residual herbicides preplant, PRE, or POST as part of the total weed management program with LibertyLink soybean varieties to prevent possible resistance development to the Liberty class of chemistry.
- A residual Group 15 herbicide should be tank-mixed with a POST herbicide application.
- In a soybean-corn rotation, producers should be mindful that Palmer pigweed can produce a crop of seed after corn harvest, and act accordingly by removing those plants.
- **There is no economic threshold for pigweed management; thus, near-zero tolerance is required each year. Mechanical and/or hand removal of pigweed escapes should be done immediately to prevent pollen and/or seed production.**

*Composed by Larry G. Heatherly, revised May 2020,
larryheatherly@bellsouth.net*

Herbicide Programs to Manage Herbicide-Resistant Palmer Amaranth	
Preplant/PRE Herbicide (MOA Group)	POST Herbicides (MOA Group)
Roundup Ready System	
Anthem (14 + 15), Authority XL (2 + 14), Authority MTZ (5 + 14), Authority Elite (14 + 15), Authority Maxx (2 + 14), Boundary (5 + 15), Canopy (2 + 5), Canopy EX (2), Envive (2 + 14), Fierce (14 + 15), Gangster (2 + 14), Optill (2 + 14), Prefix (14 + 15), Pummel (2 + 15), Sharpen (14), Sonic (2 + 14), Surveil (2 + 14), Torment (2 + 14), Valor (14), Valor XLT (2 + 14), Verdict (14 + 15), or Zidua (15).	Glyphosate (9) + Prefix (14 + 15), Glyphosate (9) + Dual (15), Flexstar (14), Reflex (14), Flexstar GT (9 + 14), Glyphosate (9) + Warrant (15), Sequence (9 + 15), or Torment (2 + 14).
Liberty Link System	
Anthem (14 + 15), Authority XL (2 + 14), Authority MTZ (5 + 14), Authority Elite (14 + 15), Authority Maxx (2 + 14), Boundary (5 + 15), Canopy (5 + 2), Canopy EX (2), Envive (2 + 14), Fierce (14 + 15), Gangster (2 + 14), Optill (2 + 14), Prefix (14 + 15), Pummel (2 + 15), Sharpen (14), Sonic (2 + 14), Surveil (2 + 14), Torment (2 + 14), Valor (14), Valor XLT (2 + 14), Verdict (14 + 15), or Zidua (15).	Liberty (10), Liberty (10) + Dual (15), or Liberty (10) + Warrant (15).
Xtend System	
Valor (14), Fierce (14 + 15), Envive (2 + 14), Authority XL (2 + 14), Canopy (5 + 2), Boundary (5 + 15), Surveil (2 + 14); add Dual Magnum (15), Warrant (15), or Zidua (15) for grass control.	Xtendimax (4) or Engenia (4); Glyphosate (9) + Dual (15) or Warrant (15) for residual control.
Conventional (Non-GMO) System	
Anthem (14 + 15), Authority XL (2 + 14), Authority MTZ (5 + 14), Authority Elite (14 + 15), Authority Maxx (2 + 14), Boundary (5 + 15), Canopy (2 + 5), Canopy EX (2), Envive (2 + 14), Fierce (14 + 15), Gangster (2 + 14), Optill (2 + 14), Prowl (3), Pummel (2 + 15), Sharpen (14), Sonic (2 + 14), Surveil (2 + 14), Torment (2 + 14), Treflan (3), Valor (14), Valor XLT (2 + 14), Verdict (14 + 15), or Zidua (15).	Reflex (14), Flexstar (14), Ultra Blazer (14), Cobra (14), Prefix (14 + 15), or Torment (2 + 14).
<ul style="list-style-type: none"> All herbicides listed for use in each of the above systems control weeds other than pigweed, and each likely offers better control of some weeds vs. other listed herbicides. Therefore, herbicides from the above list should be selected to manage other broadleaf and grass weed species that may be present in an individual field and that are listed as controlled by the chosen herbicide(s) or herbicide premixes. Authority MTZ, Boundary, and Canopy contain Metribuzin. Check selected varieties to ensure tolerance to this herbicide component. For estimated levels of weed control normally expected with above herbicides, see Weed Control Guides from the Midsouth states. 	

MANAGING HERBICIDE-RESISTANT PALMER AMARANTH IN MISSISSIPPI SOYBEAN

Information in the [Feb. 18 2016 edition of AgFax Weed Solutions](#) confirms that a significant portion of the Palmer pigweed population in the Midsouth is resistant to PPO herbicides (Group 14), and the magnitude of this resistance is likely to increase. This adds another layer of resistance to herbicides in this weed, and further complicates management systems for its control.

PPO resistance means that herbicides such as Flexstar/Reflex, Sharpen, and Valor (click [here](#) for all herbicides in the PPO inhibitor group 14), which have been applied for pigweed control for several years, have likely been overused to the extent that Palmer has developed resistance to the herbicides in this MOA group.

According to Dr. Larry Steckel, UT Associate Professor and Row Crop Weed Specialist who is quoted in the above AgFax article, Liberty (and compatible glufosinate products—herbicide Group 10) is the last herbicide that will control Palmer amaranth post-emergence in soybeans where PPO resistance is a factor. His recommendations for using Liberty herbicide in LibertyLink soybeans are provided. Briefly, they are:

- Coverage with Liberty or equivalent glufosinate products is critical, and applying in at least 15 gallons of water is recommended.
- The time of day that glufosinate is applied directly influences pigweed control. Best results are achieved if Liberty is applied in a window from 2 hours after sunrise to about an hour before sunset.
- In soybeans, consider mixing a PPO herbicide with glufosinate to achieve more consistent control of Palmer pigweed.
- Utilize cultural weed control practices such as cover crops.
- Rotate soybeans with corn or grain sorghum so that herbicides with other MOA's are used.

In response to this additional resistance to PPO herbicides in Palmer pigweed, Mississippi specialists (Drs. Jason Bond, Trent Irby, and Dan Reynolds) posted an article on the Mississippi Crop Situation blog site that provides additional narrative on the subject. That article is appended here. They also compiled a soybean weed control guide to reflect the potential for PPO-resistant pigweed, as well as pigweed's current resistance to glyphosate and ALS (Group 2) herbicides. That guide is appended here, along with choices of residual herbicides to use.

Managing PPO-resistant Palmer Amaranth in Mississippi Soybean

*By Jason Bond, Research/Extension Weed Scientist, Dan Reynolds, and Trent Irby, Extension Soybean Specialist,
March 25, 2016*

The protoporphyrinogen oxidase (PPO) herbicides (herbicide Group 14) have been one of the primary herbicide chemistries for control of Palmer amaranth in Mississippi soybean over the last six to eight years. Based on greenhouse screening, fields located in Bolivar, Coahoma, Sunflower, and Tunica counties or in counties adjacent to these likely contain Palmer amaranth resistant to PPO herbicides. The presence of PPO-resistant Palmer amaranth will complicate herbicide programs in affected areas. Most populations of Palmer amaranth in the Mississippi Delta exhibit multiple resistance to glyphosate and ALS herbicides (herbicide Group 2; Classic, Envoke, Regiment, Staple).

Suggested [herbicide programs](#) (Information Sheet 2022) in Mississippi soybean have been updated to address multiple resistance to glyphosate, ALS, and/or PPO herbicides in Palmer amaranth. PPO herbicides are still a prominent part of this program. Residual applications of PPO herbicides still offer some control of PPO-resistant waterhemp (a pigweed species closely related to Palmer amaranth) in midwestern states. However, the level of control and length of residual is lower on resistant compared with susceptible populations. Preliminary data from the University of Arkansas shows a similar response in PPO-resistant Palmer amaranth. Therefore, the use of herbicide mixtures containing multiple effective modes of action is critical in areas with PPO-resistant Palmer amaranth.

The updated [herbicide programs](#) for managing multiple resistant Palmer amaranth in Mississippi soybean include a preplant application 14 to 21 days prior to planting and after final bed preparation in fields with targeted planting date later than April 15. This application should contain paraquat at 0.75 lb active ingredient/acre to control Palmer amaranth emerged at application.



All herbicide mixtures suggested for use in the preplant timing include a residual PPO herbicide plus a herbicide representing Group 15. Herbicides in Group 15 are very long chain fatty acid synthesis inhibitors (VLCFAs), and those recommended for use in Mississippi soybean include metolachlor or S-metolachlor, Warrant, Zidua, and the Anthem brand of products (Caution: Warrant should be applied when temperatures are warm, as colder weather may reduce activity due to encapsulation degradation kinetics.).

Regardless of targeted soybean planting dates, preemergence applications should be made before soybean emergence up to 7 days prior to planting. As with the preplant, preemergence applications should contain paraquat at 0.75 lb active ingredient/acre. Herbicide mixtures suggested for use in the preemergence timing include metribuzin and a Group 15 herbicide. Some soybean varieties are susceptible to injury from metribuzin. Furthermore, soil pH and texture directly influence metribuzin activity. Soil test results along with seed and herbicide manufacturer information should be consulted to ensure the correct combination of variety and metribuzin rate.

Postemergence herbicide applications should be made 7 to 21 days after soybean planting with precise timing dictated by efficacy of preplant and/or preemergence treatments, soybean growth rate, and

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environmental conditions. Earlier applications should be utilized if previous treatments were not incorporated or when temperatures are warm and soybean and/or existing weeds are growing rapidly.

Herbicide mixtures suggested for postemergence use in the Roundup Ready system include glyphosate, fomesafen, and a Group 15 herbicide. In Mississippi counties with known populations of glyphosate- and/or PPO-resistant Palmer amaranth or in areas where unexplained herbicide failures occurred in 2015, postemergence herbicide applications should be timed earlier because efficacy on emerged Palmer amaranth will likely be poor and the residual activity of the herbicide mixture should be utilized to prevent new emergence.

The only postemergence herbicide that controls multiple resistant Palmer amaranth after crop emergence is Liberty 280 (herbicide Group 10). Liberty 280 may only be applied to LibertyLink soybean varieties. It is primarily a contact herbicide, so weed size at application, application volume, nozzle selection, and time of day of application are all critical to optimize herbicide performance. Liberty 280 applications should target Palmer amaranth seedlings no greater than 3 to 4 inches in height.

Addressing issues with multiple resistant Palmer amaranth requires development of sound “weed management” programs and not just attempts at “weed control” with herbicides. Scouting fields is critical. Check closely for efficacy following all herbicide applications so appropriate decisions can be made quickly. Use all possible tactics to combat Palmer amaranth. Cultural practices such as variety selection, row spacing, planting date, hand-weeding, etc. are critical, especially as the number of effective herbicides continues to decline. These strategies also assist in managing the weed soil seedbank. The soil seedbank is the key to the Palmer amaranth problem. If it is not managed, Palmer amaranth WILL get worse.



Palmer amaranth will produce tremendous numbers of seed growing in soybean.

Managing Palmer amaranth with multiple resistance to glyphosate, ALS, and PPO herbicides in Mississippi soybean will be complicated; however, control of this species is still feasible. Please contact me if you suspect a problem.



Programs for Managing Herbicide-Resistant Palmer Amaranth in Mississippi Soybean¹

System	Preplant ^{2, 3}	Preemergence ^{3, 5}	Postemergence ^{6, 7}	Salvage ^{7, 8}
Roundup Ready	Authority Elite; Fierce; Envive, Sharpen, Sonic, Surveil, Valor XLT, or Verdict + Group 15 herbicide ⁴	Boundary; Authority MTZ, Canopy, or metribuzin + Group 15 herbicide ⁴	Glyphosate + fomesafen + Group 15 herbicide ⁴	Glyphosate + Cobra or Ultra Blazer
LibertyLink	Authority Elite; Fierce; Envive, Sharpen, Sonic, Surveil, Valor XLT, or Verdict + Group 15 herbicide ⁴	Boundary; Authority MTZ, Canopy, or metribuzin + Group 15 herbicide ⁴	Liberty 280 + fomesafen + Group 15 herbicide ⁴	Liberty 280
Conventional	Authority Elite; Fierce; Envive, Sharpen, Sonic, Surveil, Valor XLT, or Verdict + Group 15 herbicide ⁴	Boundary; Authority MTZ, Canopy, or metribuzin + Group 15 herbicide ⁴	Cobra, fomesafen, or Ultra Blazer + Group 15 herbicide ⁴	Cobra or Ultra Blazer

¹The information given here is for educational purposes only. References to commercial products, trade names, or suppliers are made with the understanding that no endorsement is implied and that no discrimination against other products or suppliers is intended.

²**Preplant applications should be made 14 to 21 days before planting and after final bed preparation in fields with targeted soybean planting date later than April 15. A preemergence application should be made before crop emergence.** Control with residual herbicides will be compromised if beds are disturbed after application.

³**Paraquat at 0.75 lb ai/acre plus surfactant should be mixed with residual herbicides to control Palmer amaranth emerged before application.** The use of full labeled rates of residual herbicides is imperative for herbicide-resistant weed management. Soil applications of residual herbicides require incorporation from rainfall or irrigation, and level of control and length of residual will vary with rainfall totals. When properly incorporated, residual herbicides can control Palmer amaranth for 2 to 3 weeks depending on time of year, soil moisture, and weed pressure.

⁴Herbicides in Group 15 are very-long-chain fatty acid synthesis inhibitors (VLCFAs). Group 15 herbicides recommended for use in Mississippi soybean include metolachlor or S-metolachlor, Warrant, and Zidua. Warrant should be applied when temperatures are warm; colder weather may reduce activity. Herbicide labels should be consulted for seasonal maximum use rates and rotation intervals to other crops.

⁵**For all targeted soybean planting dates, preemergence applications should be made before soybean emergence up to 7 days before planting.** All listed residual herbicides for preemergence application contain metribuzin. Some soybean varieties are susceptible to injury from metribuzin. Manufacturer information should be consulted during variety selection for level of metribuzin tolerance.

⁶**The postemergence application should be made 7 to 21 days after soybean planting with precise timing dictated by efficacy of preplant and/or preemergence treatments, soybean growth rate, and environmental conditions.** Earlier applications should be used if previous treatments were not incorporated or when temperatures are warm and soybean and/or existing weeds are growing rapidly.

⁷Spray coverage is critical for weed control with contact herbicides such as Cobra, fomesafen, Ultra Blazer, and Liberty 280. Applicators should be equipped with nozzles that ensure thorough spray coverage. Nozzles producing coarse droplets should not be used for contact herbicides.

⁸Salvage treatment should target escaped Palmer amaranth not controlled by earlier applications.

Information Sheet 2022 (POD-10-18)

By **Jason Bond**, PhD, Extension/Research Professor, Delta Research and Extension Center; **Trent Irby**, PhD, Associate Extension Professor, Plant and Soil Sciences; and **Daniel Reynolds**, PhD, Professor and Endowed Chair, Plant and Soil Sciences.



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MANAGING HERBICIDE-RESISTANT PIGWEED IN XTEND SOYBEANS

Dr. Larry Steckel, UT Extension Weed Specialist at Jackson, Tenn., has posted several articles that provide options for controlling multiple-resistant Palmer amaranth, including those in dicamba-tolerant Xtend soybeans. A short summary of each article (shown in bold and appended below) follows.

“Recent Midsouth Studies Show Dicamba not very Effective on some Populations of Glyphosate/PPO-Resistant Palmer Amaranth.”

Don't assume that Engenia or Xtendimax dicamba herbicides will automatically control all Palmer amaranth. In Dr. Tom Barber's (Arkansas Weed Scientist) plots that Dr. Steckel visited in Crittenden County Arkansas, it was obvious that dicamba applied to small Palmer amaranth provided less than optimal control. The only herbicides that appeared to work best in the viewed trials were atrazine and Liberty.

Following the viewing of these trials and noting their results, screenings were conducted on Palmer amaranth biotypes from Shelby County, Tenn. plus biotypes from Knox County, Tenn. These screenings produced the same results on the Shelby County biotypes as those viewed in the Arkansas trials, but interestingly, the Palmer amaranth samples from Knox County, Tenn. showed 95% control by dicamba compared to only 65% control of the West Tenn. biotypes.

Dr. Steckel's conclusions are:

- There is a good chance that some Palmer amaranth will escape control by Engenia and Xtendimax herbicides; scouting will be critical to ensure that dicamba applications have in fact controlled this targeted weed.
- PRE herbicides/herbicide mixes that contain an efficacious component against Palmer amaranth must be used.
- Herbicides with known resistance issues against targeted weeds should not be abandoned, but rather should be combined with other residuals that have good activity against Palmer amaranth.

“Controlling Multiple-Resistant Palmer Amaranth.”

Results from a survey of West Tennessee soybean fields found that 83% of tested fields had Palmer amaranth populations that were resistant to fomesafen (PPO inhibitor–Group 14), and subsequent field research showed that these populations are also resistant to ALS herbicides (ALS inhibitors–Group 2) and glyphosate. Subsequent research was conducted to determine the effectiveness of various herbicides in controlling PPO-resistant Palmer amaranth compared to a location with Palmer amaranth populations that were still susceptible to PPO-inhibiting herbicides. Findings/determinations from this activity follow.

- XtendiMax (dicamba) and Enlist Duo (2,4-D+glyphosate) herbicides provided 80% control at the PPO-resistant site and 100% control at the PPO-susceptible site. Liberty provided 90% and 100% control at the two respective sites, whereas atrazine provided 100% control at both sites. Flexstar (fomesafen) provided ~28% control at the PPO-resistant site and nearly 100% control at the PPO-susceptible site.
- Interestingly, even though Flexstar applied alone did not control the PPO-resistant Palmer, it did control the Palmer that had escaped the initial application of dicamba. Thus, it appears that Flexstar is of value for controlling weakened Palmer amaranth following a dicamba application.
- From a stewardship standpoint (reduced potential for offsite drift of auxin herbicides and optimum resistance management from applying 2 modes of action), applying an auxin herbicide (either dicamba or 2,4-D) as the first POST application followed 7-10 days later with Flexstar provides good control of any escapes and potentially removes the need for a second application of an auxin herbicide.

“Palmer Amaranth Management Strategies in Xtend Soybean”.

Dr. Steckel provides weed control options for the following two scenarios.


1) ***Xtend soybeans are planted but there is no intention of applying POST dicamba.*** He strongly recommends planting soybeans in rows that are ≤20 inches wide in a field free of weeds, and applying a PRE herbicide with at least two modes of action (see example herbicides listed in linked article) that are effective against Palmer amaranth. If a premix that contains metribuzin is used, he recommends increasing the rate of metribuzin in the mix. This should be followed by POST applications of Prefix or Anthem (both Group 15+14) or Zidua (Group 15) herbicides no later than 10-14 days after the PRE application. If all components of this plan are included, the likelihood of controlling glyphosate-, PPO-, and ALS-resistant Palmer amaranth is high.

2) ***Xtend soybeans are planted and either Engenia or XtendiMax dicamba herbicides will be applied POST.*** As in system 1) above, plant in narrow rows in a field free of weeds and apply PRE residual herbicides as indicated. Before Palmer amaranth reaches 4 inches tall, apply the dicamba herbicide POST. Follow that 7-10 days later with a POST application of a fomesafen-based herbicide like Prefix or Warrant Ultra to remove any pigweed escapes.

A final note. Under no circumstances should growers rely solely on POST-applied dicamba herbicide for weed management in soybeans just as they should not have relied solely on POST-applied glyphosate. If this is done, it will lead to the same result—the end of the usefulness of the technology as an additional tool for weed control in soybeans. It is imperative that the PRE component of the weed control strategies outlined above be an integral part of weed management programs that use auxin-tolerant soybeans with auxin herbicides applied POST.

Click [here](#) for a White Paper that elucidates how to use herbicide mode of action (MOA) in soybean weed control strategies.

Recent Midsouth Studies Show Dicamba not Very Effective on some Populations of Glyphosate/PPO-Resistant Palmer Amaranth.

 news.utcrops.com/2017/05/recent-midsouth-studies-show-dicamba-not-effective-populations-glyphosateppo-resistant-palmer-amaranth/

May 4, 2017

Larry Steckel, Ext. Weed Specialist

Last summer Dr. Tom Barber, University of Arkansas weed scientist, invited me to visit his field research on glyphosate/PPO-resistant Palmer amaranth in Crittenden County, Arkansas. As was expected glyphosate and Flexstar provided very poor Palmer amaranth control in his tests.

What was not expected is that a number of other herbicides provided poor control as well. Even dicamba at 0.5 lbs/A (Clarity 16 oz) on small Palmer amaranth provided less than optimal control. The only herbicides that still appeared to work in those trials were atrazine and Liberty. Until I had visited those Arkansas locations I had not seen dicamba on small Palmer amaranth perform that poorly. It was concerning to say the least and as a result we decided to screen Palmer amaranth on the Tennessee side of the river also.

We sent Palmer amaranth that we were confident was glyphosate/PPO resistant from north Shelby County, Tennessee to my colleague Dr. Tom Mueller in Knoxville last fall. He had a graduate student, Alinna Umphres, that subsequently screened this Palmer amaranth for its tolerance to a number of herbicides applied POST. As a check, the researchers also screened Palmer amaranth sourced from Knox County that was known to be resistant to glyphosate but not to PPO herbicides. The herbicides chosen to screen were then applied to the Palmer when it was 4" tall.

The results are below. In short, the Shelby County Palmer amaranth population, as expected, was resistant to glyphosate, Flexstar and Classic. Unfortunately, just like in Crittenden County, the Palmer amaranth also showed tolerance to dicamba and mesotrione. Moreover, just like the research in Arkansas the Palmer amaranth was still readily controlled by atrazine and Liberty.

In the table below the average control for each herbicide by population is compared. The column to the far right labeled $Pr>F$ gives a number for each comparison. The smaller that number the higher the probability that there is a real difference between the populations for that herbicide. This number is important for this type of comparison as the populations are not pure. For example with Clarity about 2/3 of the plants screened for Shelby county were controlled less than 60% (a number showed <5% control) while 1/3 of the population was controlled 100%. In contrast, all the Knox county pigweed plants were controlled better than 92% 14 days after application.

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So what is going on? It is known that the PPO-resistance in our Shelby County population has at least 3 different genes for resistance to PPOs. However, we are still finding Palmer amaranth that is resistant to PPO herbicides but does not contain any of those genes. A possible reason is a 4th resistance mechanism is metabolism-based where the plant is producing enzymes that tie up the PPO herbicides. These enzymes can also tie up other herbicides as well. Last year's field data from Arkansas and now this greenhouse data from Tennessee would suggest that metabolism could very well be an issue for at least some of our PPO-resistant Palmer amaranth in the Midsouth.

So what does this mean for us? This spring in some areas like Crittenden County in Arkansas and Shelby and Tipton Counties in Tennessee there is a good chance that some Palmer amaranth will escape Engenia or Xtendimax applications. Therefore scouting will be critical. Do not assume because Engenia or Xtendimax have been sprayed on Palmer amaranth that they will all be controlled. Have eyes on the field that confirm they are controlled.

So what do we do? Diversity is still the key. PRE applied herbicides containing a good residual for control of Palmer amaranth must be used. Then overlap a POST emergence that has good residual activity on pigweed prior to the PRE playing out, even in Xtend and LL crops. Moreover, cultural methods such as narrow soybean row widths, hand weeding and cover crops will need to be used now more than ever.

Finally should we kick to the curb the herbicides that have such resistance issues? I do not think so for two reasons. First if we no longer utilize herbicides that have resistance issues we have almost none to choose from. Second, even with ones like fomesafen that will miss a lot of Palmer amaranth POST, they still provide a lot of weed control help applied PRE. They just can no longer be applied alone but tankmixed with another good residual herbicide for pigweed like metribuzin, Dual Magnum, Zidua, etc.

Rating taking 14 DAA	Knox County Palmer	Shelby County Palmer	
	————-% Control————		Pr>F
Flexstar 16 oz/A	91	39	0.0026
Clarity 16 oz/A	95	65	0.0969
Classic 0.5 ozs/A	10	17	0.6365
Roundup PowerMax 32 ozs/A	11	12	0.9870
Callisto 3 ozsA	89	58	0.0911
Atrazine 32 ozs/A	85	93	0.5545

Liberty 29 ozs/A	91	97	0.7336
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Controlling Multiple-Resistant Palmer Amaranth

 news.utcrops.com/2018/03/controlling-multiple-resistant-palmer-amaranth/

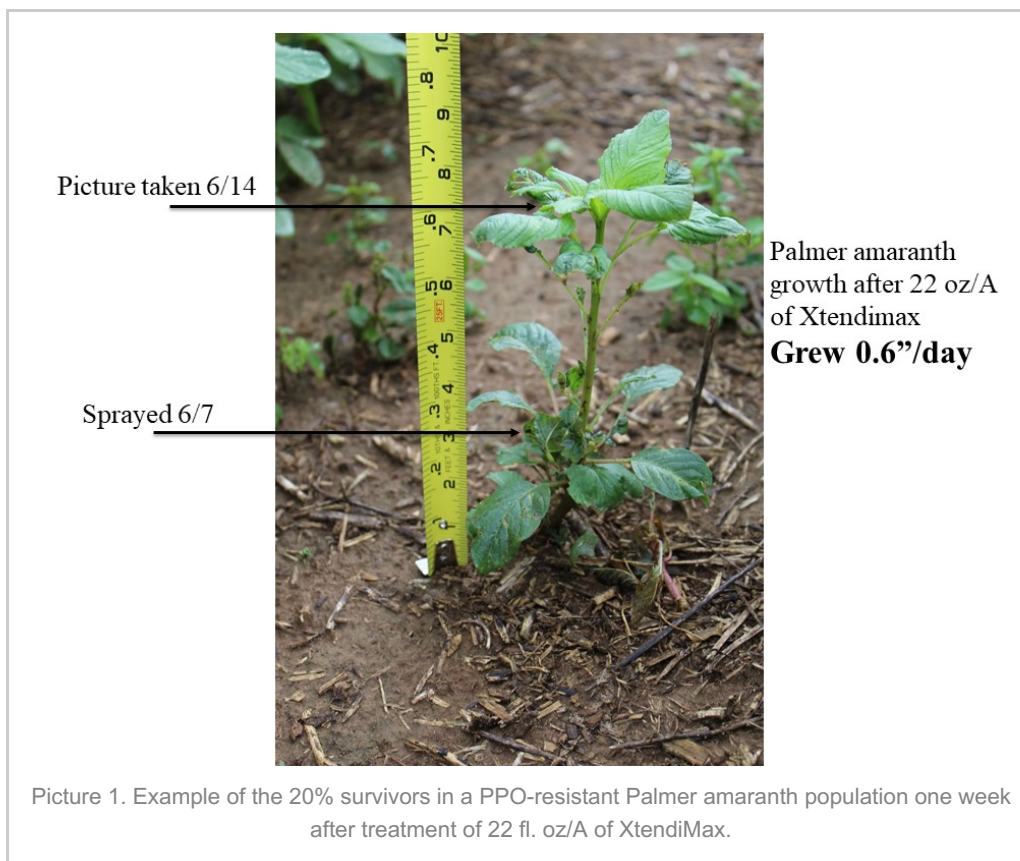
Larry Steckel, Ext. Weed Specialist

March 6, 2018

A survey sponsored by the Tennessee Soybean Promotion was conducted last summer to determine the percentage of fields that harbored PPO-resistant Palmer amaranth in West Tennessee. We found that 83% of the fields tested had Palmer amaranth infestations that survived a field use rate of Flexstar (fomesafen). Recent field research has shown that these populations are also ALS & glyphosate-resistant.

Additionally, some of these multiple-resistant Palmer amaranth populations are proving to be difficult to control with a number of herbicides. So research was conducted to investigate the effectiveness of various herbicides in controlling PPO-resistant (Flexstar-resistant) Palmer amaranth compared to a location where PPO herbicides were still effective on Palmer.

The herbicides tested were applied to pigweeds that were 2 to 4" in height. XtendiMax (Picture 1) and Enlist Duo provided about 80% control of the Palmer amaranth at the PPO-resistant site compared to 100% control at the PPO-susceptible-site

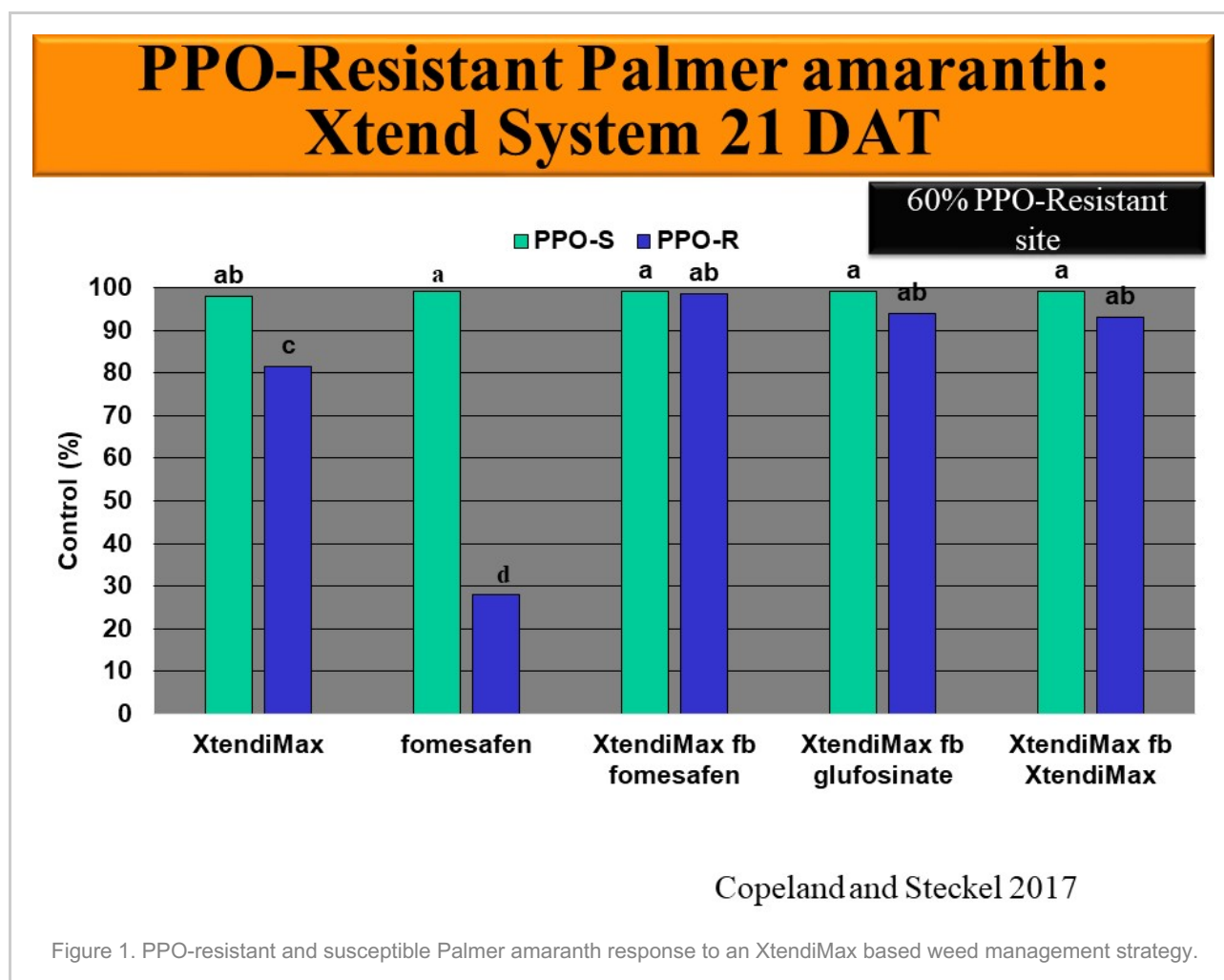


Other herbicides that did not perform as well as we would like at the PPO-resistant site were Liberty (90% compared to 100% at PPO-S) and Callisto (38% compared 90%). The only herbicide tested that provided 100% control of Palmer amaranth at both sites was atrazine.

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It is unclear at this point of how to label this biotype of Palmer amaranth that resides on both sides of the Mississippi River around and just north of Memphis. Is it resistant to all those herbicides? Is it just the background tolerance that has always been there? That is still being determined. The best theory to date is that some kind of metabolic resistance is building in the Memphis area Palmer amaranth biotype that gives the weed some tolerance to a multiple classes of herbicides.

So what is a good approach to control Palmer amaranth in locations where PPO-resistant Palmer amaranth is present? The graph below shows the results of a comparison of the efficacy of herbicides at a PPO-susceptible (PPO-S) Palmer amaranth site and a PPO-resistant (PPO-R) Palmer location (Figure 1). Treatments were applied alone or with a sequential application made 7 days later. Treatments included: XtendiMax at 22 fl. oz./A; Flexstar at a pint/A; XtendiMax followed by Flexstar; XtendiMax followed by Liberty at 32 fl oz./A ; and XtendiMax followed by XtendiMax.



Flexstar (fomesafen) applied alone provided ~28% control at the PPO-R location (Figure 1). Hence, the need for auxin-tolerant crops. Interestingly, Flexstar applied 7 days after the initial XtendiMax application controlled Palmer amaranth (Picture 1) that escaped the initial dicamba application at the PPO-R site. So, even though Flexstar applied alone would not control these Palmer amaranth, it would control them if they were recovering from a dicamba application.

We speculate that the initial application of dicamba affected the mechanism of PPO-resistance

enough that the Palmer amaranth can then be controlled with a follow-up PPO-inhibiting herbicide.

From a stewardship standpoint, applying an auxin (i.g. dicamba or 2,4-D) in the first POST application is the best strategy. Following that application, 7 to 10 days later, with Flexstar (in soybeans) or Liberty (in cotton) provides good control of any escapes and potentially removes the need for an application of dicamba later in the season. This strategy may help avoid off-target movement and is also good resistance management.

Palmer Amaranth Management Strategies in Xtend Soybean

 news.utcrops.com/2018/03/palmer-amaranth-management-strategies-xtend-soybean/

Larry Steckel, Ext. Weed Specialist

March 13, 2018

As of Monday we have had well over 2400 folks take the dicamba training in Tennessee. Our best estimate is that about 2500 total would be spraying Engenia or XtendiMax in Xtend crops so we are clearly in the short rows for getting applicators trained. If you still lack the dicamba training, contact your county Extension Agent.

Since most are now trained to apply dicamba, questions have arisen on strategies to manage Palmer amaranth in Xtend soybean under two different situations. The first situation is for soybean fields where the grower has no intention to use dicamba POST in crop. This is a good strategy in my mind for fields near sensitive crops or perhaps near neighbors where drift was an issue last year.

My first thought when answering this question is overlaying residuals. Make sure the soybeans are planted in narrow rows (20" or less) in a field clean of weeds and use a good PRE applied herbicide with two modes of action effective on Palmer amaranth. There are a number of good options here so in alphabetical order they include: Authority Elite, Authority MTZ, Boundary, Broadaxe, Fierce and Zidua + metribuzin just to name a few. One might question the PPO-based herbicides in the list in fields with PPO-resistant Palmer amaranth. In our research we still get 80% control of PPO-resistant Palmer amaranth for 21 days with either fomesafen or sulfentrazone. Of course, in PPO-susceptible Palmer amaranth we would get 100% control through 21 days after application which is why the Dual Magnum or metribuzin premixes are recommended.

The typical premix rate containing metribuzin provides 4 to 4.5 oz/s of metribuzin. Consider spiking that metribuzin rate up to 5.5 to 6 ozs on the silt loam soils for longer, more consistent Palmer amaranth control.

Then the main key to success is to apply Prefix, Anthem or Zidua POST no later than 10 to 14 days after the PRE. This is the critical part of the plan that if missed can result in a grown up pigweed mess. If Palmer is allowed to emerge, particularly in much of west Tennessee where it is glyphosate-, PPO- and ALS-resistant, there are no herbicide options. However, if that overlaying residual can get applied and activated, it should provide enough residual Palmer control to get to crop canopy in narrow row soybeans.

The other question is what is a good way to utilize either Engenia or XtendiMax in Xtend soybeans to manage Palmer amaranth? The answer starts the same as above with planting into a clean field. Of course, Engenia and XtendiMax would be good tools to help start clean. A PRE is needed in this system as well for consistent weed control. Any of the ones mentioned above would work well.

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Then before the Palmer reaches 4" in height apply the Engenia or XtendiMax POST. After that, consider utilizing a fomesafen-based herbicide like Prefix or Warrant Ultra to remove any pigweed escapes 7 to 10 days after the Engenia or XtendiMax application. The dicamba followed by a fomesafen-based product worked well even on PPO-resistant Palmer amaranth populations in research last year. Moreover, it also worked for a number of growers who utilized that strategy on thousands of Xtend soybean acres in 2017.

Speaking of last year, I know we had some who did not use a PRE and relied exclusively on POST applied Engenia plus glyphosate as often as needed. This is a very short-sighted approach that will spell the early end of the technology. Stick with the best management practices outlined on the label and mentioned above.