Conservation Systems Research

Controlling Glyphosate–Resistant Pigweed in Conservation Tillage Cotton Systems

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Palmer amaranth (*Amaranthus palmeri*), a pigweed species, has developed glyphosate resistance and has become the most important weed problem in the southeastern and mid–south US. A prolific seed producer (200,000+ seeds per plant), Palmer amaranth populations can quickly develop from a few plants into a major infestation if not quickly controlled. Resistance is spread mainly by equipment and also through pollen, so it can transfer quickly into neighboring populations.

Palmer amaranth inflorescence.
Photo courtesy of Shawn Askew, Virginia Tech.

Conservation tillage systems that reduce or eliminate plowing or cultivation rely on chemical and cultural weed control methods. These include:

1. Intensive crop and herbicide rotation to avoid development and spread of resistant amaranth.
2. Managing winter cover crops to produce high levels of residue that will suppress weed germination and growth.
3. Spot–spraying or hand removal to control small, early infestations.
4. Integration of soil–active and post–emergence herbicides throughout the growing season to suppress weed germination and growth.

Cotton infested with Palmer amaranth. Note female and male plants in center. *Photo courtesy of Michael Patterson, Auburn University.*

Crop rotation and herbicides

In any production system, herbicide resistance is best avoided and reduced by rotating crops and herbicides that are effective against the target weeds.

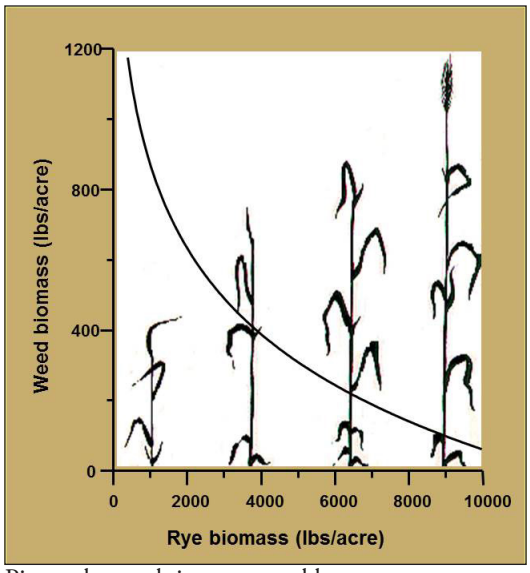
Rotating cotton with other crops and using herbicides with different modes of action will discourage the development of resistant weeds. There are herbicides available for use in corn, peanut, soybean, and other crops that offer excellent Palmer amaranth control.

Weeds must be controlled throughout the summer. Palmer amaranth can germinate and produce seeds late in the season, even after crop harvest. For example, after corn harvest, Palmer amaranth can emerge and set seed.

High–residue cover crops

High–residue cover crops in conservation tillage systems offer effective weed suppression. When the winter cover is planted early and managed for maximum growth, a dense residue mat is formed on the soil surface. Many producers are also minimizing soil and residue disturbance by using direct seeding or narrow strip tillage, which drastically reduces weed seed germination within the row.

Since weed emergence and growth is suppressed by the physical barrier and shading of the residue, more residue results in better weed control. Cover crop residue will not successfully control pigweed unless the residue is heavy and minimally-disturbed. Additionally, most cover crop residues leach allelopathic chemicals that inhibit weed germination and/or growth.



Pigweed growth is suppressed by cover crop residue, the more the better. [*Source: Price et al., 2016*]

An experiment in Alabama showed that cereal rye cover crop residue is very effective for controlling pigweed. The rye was planted at three different dates in late fall and allowed to grow through the winter and early spring before being killed and rolled prior to planting a cotton crop. The earlier-planted rye produced greater residue and was most effective at controlling pigweed density (and pigweed biomass). Treatments with winter fallow and traditional tillage (multiple disking and cultivating) had greater pigweed density (and pigweed biomass not shown).


Palmer amaranth seedling. Control it early before seed production. *Photo courtesy of Shawn Askew, Virginia Tech.*

Spot-spray/hand weeding

Palmer amaranth usually appears in small patches of one or a few plants the first year. If found and removed before seeds are produced, the problem can be eliminated before it spreads. If seeds are produced, they will be spread by farm equipment across and among fields.

Plants can be killed by hand, hoe, or spot-spraying. They must be removed from the field; otherwise, pulled plants can re-root and produce seed.

Soil–active and post–emergence herbicides

The University of Georgia has developed aggressive herbicide programs to control glyphosate–resistant Palmer amaranth. Modified versions for conservation systems are included here (see last page). Use these to control weed populations that have become established in your cotton fields. In cotton, directed sprays are necessary.

In high–residue conservation systems, cover crop residues can intercept soil–applied herbicides and reduce their effectiveness.

In-row pre-emergence applications will control weeds not covered by residue. *Photo courtesy of David Harkins, Alabama Agricultural Experiment Station.*

What about strategic tillage?
Some advocate moldboard-plowing infested areas to deeply bury resistant pigweed seed. This can greatly reduce Palmer amaranth emergence; however, there are concerns with this method:

- Moldboard plowing is not 100% efficient at inverting soil. It is dependent on soil texture, soil moisture, and operation speed. Some resistant seed will be left on or near the soil surface where they will germinate. Other control methods will also be needed.
- Since resistance is transferred via wind-borne pollen from neighboring fields and non-cropland, neighboring land will likely be a continual source of resistant Palmer amaranth pollen. Plowing will not control this.
- Plowing and cultivating a field more than once during the lifetime of a Palmer amaranth seed (up to eight+ years) will likely bring resistant seeds back to the surface.

Producers who are new to conservation tillage or not growing high-residue winter cover crops may consider plowing as an option. Those who currently use high-residue cover crops in mature conservation tillage systems may reject plowing because it would destroy the cumulative agronomic benefits built over time.

Herbicide Programs for Palmer Amaranth Control in Conservation-Tillage Cotton

Herbicide program recommendations adapted from: ***Culpepper, A.S., A.C. York, J. Kichler, and J. Smith. 2016. UGA Programs for Controlling Glyphosate-Resistant Palmer Amaranth in 2016 Cotton. Available at: http://extension.uga.edu/publications/detail.cfm?number=C952.***

Step 1: Regardless of cotton technology, in conservation tillage[1] systems growers must ensure no pigweeds are emerged at planting

Option	Chemistry	Notes
1	Valor[2] + Roundup or Gramozone[3]	Palmer <1" and over 10 d before planting
2	Valor[2] + Direx[4] + Gramozone	Palmer 1-5" and over 10 d before planting
3	Direx[4] + Gramozone	Palmer ≤ 5" and within 10 d of planting

Considerations: [1]Follow labeled plant-back intervals. Include adjuvant with Gramoxone. [2]If planting between 10 and 28 d after applying Valor, run strip-till after spraying and before planting. [3]Use Roundup if Palmer has not emerged. [4]Avoid Direx PRE if used preplant.

Step 2: Regardless of cotton technology, select and apply 2 residual herbicides PRE immediately after planting.

PRE	Herbicide Rates	Notes
1) Reflex + Warrant	1) **Reflex:** For most soils, the ideal rate is 12 oz/ac. Following Reflex preplant incorporated, 8-10 oz/ac is more appropriate.	1) Reflex systems usually provide slightly better control.
2) Reflex + Direx	2) **Warrant**: *Roundup system* likely needs 48 oz/ac except on light soil textures or under intense irrigation where 32-40 oz/ac is more appropriate. *Liberty+Roundup system* use 32-40 oz/ac.	2) Use Warrant for spiderwort. 3) Avoid more diuron if applied burndown within 14 d of planting.
3) Direx + Warrant	3) **Direx**: For most soils, the ideal rate is 10-20 oz/ac; lower rates on sands or under intense irrigation.	4) Add paraquat with the PRE mixture if pigweeds are emerged.

Minimizing injury from PRE herbicides: 1) Plant high vigor seed into moist soil (preplant irrigation often needed). 2) Shallow planting depth increases injury potential. 3) Apply proper residual herbicides within 24 hr of planting. 4) If feasible, irrigate between 30 hr after planting and prior to 24 hr before emergence but then do not irrigate again until at least 5 d after emergence. 5) Irrigated to develop a perfect cotton stand; however, limit irrigation events during the first 2 wks after planting to as few as possible after activating residual herbicides.

Step 3: Regardless of cotton technology, sequential POST applications must be timely.	
Roundup Systems	
POST 1 at 13 d after PRE[1,2]	POST 2 at 13 d after POST 1[1]
Non-ALS resistant pigweed up to 1”	*No emerged pigweed*
Roundup + Staple[3]	Roundup + Dual Magnum or Warrant
No emerged pigweed	*Non-ALS resistant pigweed up to 1”*
Roundup + Warrant or Dual Magnum	Roundup + Staple[3]
Considerations: [1]Day interval assumes PRE herbicides were ideally activated; [2]Palmer present at harvest often emerge within 17 d of planting, hence timeliness of POST 1 herbicides is critical. Pigweeds usually break through PRE herbicides between 13 and 17 d after application and activation; [3]Avoid using Staple more than once a season if possible.	
Liberty + Roundup Systems[1]	
POST 1 ~7 d after PRE[2]	POST 2 ~13-17 d after POST 1[2]
Pigweed less than 3”	*Pigweed less than 3”*
Liberty + Roundup + Dual Magnum or Warrant[3,4] **OR**	No 3-way mixture suggested
Liberty + Dual Magnum or Warrant	Liberty + Dual Magnum or Warrant
No pigweed emerged	*No pigweed emerged*
Roundup + Staple, Dual Magnum or Warrant	Roundup + Staple, Dual Magnum, or Warrant
Considerations: [1]Glytol LibertyLink Cotton or XtendFlex Cotton Cultivars Only; LibertyLink cotto nis more tolerant than to Liberty than XtendFlex and both technologies are more tolerant to Liberty than Widestrike cotton; [2]Day interval assumes PRE residual herbicides were ideally activated; [3]Mixtures of Liberty+Roundup+residual will be more injurious than Liberty+residual or Roundup+residual; experiment on limited acres. Injury of 25% with lead shed has been observed; [4]Tank mix can provide less grass control than Roundup alone, espeically for goosegrass. Use full rate Roundup (i.e. 32 oz/ac of WeatherMax). Base Liberty rate on pigweed size but suggest not exceeding 32oz/ac (rate ideal for 3” or smaller pigweed).	

Reducing the potential for POST herbicides to negatively impact yield: 1) Research suggests cotton injury near or during fruit set is more likely to be detrimental as compared to early season injury. Therefore, one should make all topical applications before 8-leaf stage of cotton growth; program above provide application intervals between PRE, POST 1, and POST 2 application to assist with this objective. 2) Research in 2015 suggested the greatest negative impact from POST herbicide applications occurred when significant injury was observed for several weeks. Thus, it is important when making sequential POST applications to minimize injury with the 2nd POST application.

Step 4: Directed layby herbicide applications are needed for nearly all acres.	
LAYBY Options[1,2]	Comments
1) Direx + MSMA	If soil type allows, apply 1 qt Direx + 1 qt MSMA + 1 qt crop oil concentrate.
2) Roundup + Direx	Direx + MSMA is a far better option for pigweed control; however, if grasses are a significant issue then Roundup + Direx (1.5 pt/ac) after cotton is at least 12” tall is in order.
Considerations: [1]To improve morningglory control consider adding Envoke 0.1-0.15 oz/ac. To improve spiderwort, pigweed, and grass resiudal control consider adding 1) Dual Magnum 1 pt/ac; 2) Warrant 2 pt/ac; 3) Zidua 1 oz/ac; or 4) Outlook 12 oz/ac. [2]See the pest control handbook for cotton stages of growth required for applications of variour herbicides.	

Related Publications

Culpepper, A.S., A.C. York, J. Kichler, and J. Smith. 2016. UGA Programs for Controlling Glyphosate-Resistant Palmer Amaranth in 2016 Cotton. Available at: http://extension.uga.edu/publications/detail.cfm?number=C952.

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