Conservation Systems Research

Controlling Glyphosate–Resistant Pigweed in Conservation Tillage Cotton Systems

SPECIAL PUBLICATION NO. 09

National Soil Dynamics Laboratory

Conservation Systems Research

Special Publication No. 09
May 2008

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

As some cotton growers have relied exclusively on glyphosate to control weeds, it was inevitable that weed resistance to glyphosate would develop. Palmer amaranth (*Amaranthus palmeri*), a pigweed species, has developed such a resistance and is becoming one of the most important weed problems in the southeastern USA. A prolific seed producer (200,000 to 1,000,000 seeds per plant), Palmer amaranth populations can quickly develop from a few plants into a major infestation if not quickly controlled.

Conservation tillage systems avoid plowing or cultivation that would destroy the soil structure and cause a loss of soil organic matter. Methods to control weeds without cultivation include:

1. Use crop and herbicide rotation to avoid development of resistant amaranth.
2. Manage winter cover crops to produce high levels of residue that will suppress weed growth.
3. Spot spraying or hand removal can control small, early infestations.
4. Pre- and post-emergence herbicides control any weeds that may germinate and survive the methods above.

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The photo on the left shows that residue inhibits pigweed growth between rows, but there is plenty of pigweed in the row where the soil was disturbed during planting. On the right, herbicide in the row complements the residue, resulting in no pigweed.

Rotation of crops and herbicides

In any production system, herbicide resistance is best avoided by rotation of crops and herbicides.

Rotating cotton with other summer crops, and using herbicides with different modes of action will discourage the development of resistant weeds.

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

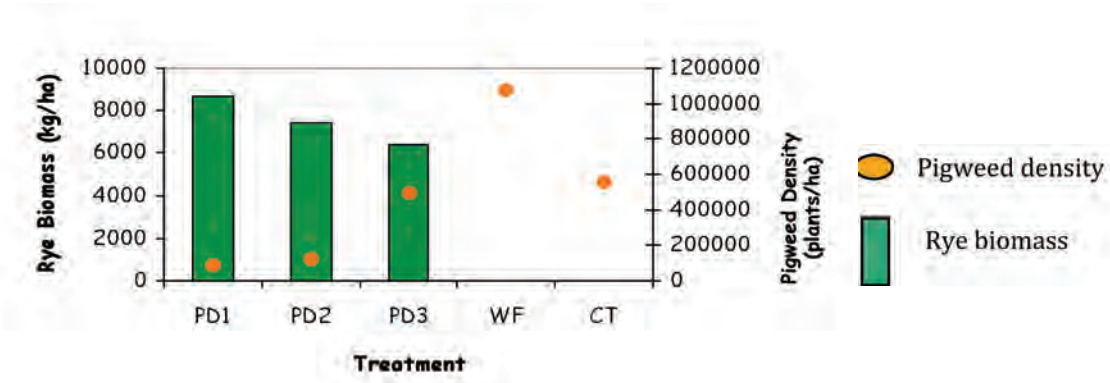
High–residue cover crops

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.

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.

An experiment in Alabama (below) showed that 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) had greater pigweed density (and pigweed biomass).



Pigweed growth is suppressed by cover crop residue, the more the better. Green bars represent rye biomass (left axis); orange dots represent pigweed density (right axis). PD1, PD2, and PD3 correspond to cereal rye planting dates 1, 2, and 3 (4 weeks prior, 2 weeks prior, and on the average first frost date). WF is winter fallow; CT is conventional tillage (multiple disking).

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. One pigweed plant can produce thousands of seeds, so removing it before this happens is important. Removal by hand, hoe, or spot-spraying can accomplish this.

Pre– and post–emergence herbicides

The University of Georgia has developed herbicide recommendations 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 high–residue conservation systems, cover crop residues can intercept soil–applied herbicides and reduce their effectiveness. Growers will find more success by banding the herbicides in the planting row, where they will get good soil contact and promote good weed control.

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

What about plowing?

Some advocate moldboard-plowing infested areas to deeply bury resistant pigweed seed. However, major pitfalls exist with this method:

- It is unlikely that moldboard plowing is 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.
- Since resistance is likely transferred via wind-borne pollen from neighboring fields and non-cropland, neighboring land must also be managed adequately.
- Plowing and cultivating a field more than once during the lifetime of a 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, use excessive amounts of fuel, time, and labor, and require equipment long-abandoned in many areas.

Herbicide Programs for Palmer Amaranth Control in Conservation-Tillage Cotton*

Table 1. Managing Glyphosate-Resistant Palmer Amaranth in Roundup Ready (RR) Cotton.*

Preemergence (PRE)	Postemergence (1- to 4-leaf cotton)	Layby Directed
Dryland Production Reflex PRE[1]	Glyphosate + Dual Magnum[3] **(no Palmer emerged)** OR Glyphosate + Staple[2] **(Palmer 1- to 2-inch)**	MSMA + Direx MSMA + Layby Pro MSMA + Suprend[2] MSMA + Valor
Irrigated Production Diuron, Prowl, or Staple[2] + Reflex PRE or Diuron + Staple[2] PRE		

* Hand-weeding and/or application of Gramoxone mixtures with hooded sprayers will likely be needed.
1. In dryland production, the addition of Diuron, Cotoran, or Staple with Reflex PRE may improve control once activated by rainfall. For those growing a dryland crop using conservation tillage, an Ignite-based program is strongly encouraged. (See Table 2.)
2. Make only one application of an ALS-inhibiting herbicide (Staple, Envoke, Suprend) per season. Will not control ALS-resistant Palmer amaranth.
3. Dual Magnum contains S-metolachlor. The generic brands Brawl and Medal also contain S-metolachlor. Other generics brands contain metolachlor, a mixture of R and S isomers. Per unit of product, brands containing S-metolachlor are more effective on Palmer amaranth and other weeds. Sequence contains a mixture of glyphosate + S-metolachlor.

Table 2. Managing Glyphosate-Resistant or Sensitive Palmer Amaranth in Liberty Link Cotton.*

Preemergence (PRE)	Postemergence (1- to 4-leaf cotton)	Layby Directed
Diuron, Prowl, or Staple[1] + Reflex PRE OR Diuron or Prowl + Staple[1] PRE	Ignite or Ignite + Dual Magnum[2] **(Palmer < 2-inch)** Ignite + Staple[1] **(Palmer < 4-inch)**	MSMA + Direx MSMA + Layby Pro MSMA + Suprend[1] MSMA + Valor

* Cotton cultivar must be resistant to Ignite 280 (glufosinate) herbicide or serious crop injury can occur.
1. Make only one application of an ALS-inhibiting herbicide (Staple, Envoke, Suprend) per season. Will not control ALS-resistant Palmer amaranths.
2. Dual Magnum contains S-metolachlor. The generic brands Brawl and Medal also contain S-metolachlor. Other generics brands contain metolachlor, a mixture of R and S isomers. Per unit of product, brands containing S-metolachlor are more effective on Palmer amaranth and other weeds. Sequence contains a mixture of glyphosate + S-metolachlor.

Table 3. Managing Moderate to Heavy Glyphosate-Sensitive Palmer Infestations in RR Cotton.

Preemergence (PRE)	Postemergence (1- to 4-leaf cotton)	Layby Directed
Cotoran, Diuron or Prowl PRE	Glyphosate + Dual Magnum[2] Glyphosate + Staple[1]	MSMA + Direx MSMA + Layby Pro MSMA + Suprend[1] MSMA + Valor Glyphosate + Direx[3] Glyphosate + Layby Pro[3] Glyphosate + Suprend[1] Glyphosate + Valor
Prowl PRE + Cotoran, Diuron, Staple[1] or Reflex PRE	Glyphosate as needed	

1. Make only one application of an ALS-inhibiting herbicide (Staple, Envoke, Suprend) per season. Will not control ALS-resistant Palmer amaranth.
2. Dual Magnum contains S-metolachlor. The generic brands Brawl and Medal also contain S-metolachlor. Other generics brands contain metolachlor, a mixture of R and S isomers. Per unit of product, brands containing S-metolachlor are more effective on Palmer amaranth and other weeds. Sequence contains a mixture of glyphosate + S-metolachlor.
3. Mixing Direx or Layby Pro with glyphosate may reduce grass control by glyphosate, especially when grasses are large and conditions dry.

* Herbicide program recommendations adapted from: *Culpepper, A.S., A.C. York, J. Kichler, A. MacRae, A.L. Davis, and T.M. Webster. 2008. University of Georgia herbicide programs for Palmer Amaranth control in cotton. Available at http://www.cropsoil.uga.edu/weedsci/HomepageFiles/Palmer2008.pdf*

Related Publications

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