



The University of Georgia

## **Managing Herbicide-Resistant Palmer Amaranth (Pigweed) In Field Corn, Grain Sorghum, Peanut, and Soybean - 2013**

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The occurrence of herbicide resistance in Palmer amaranth in Georgia is cause for significant concern for the agricultural industry. Recent changes in cropping practices, specifically the reliance on a limited number of herbicides, have streamlined weed management. However, the consequence has been the development of herbicide resistance. An effective herbicide-resistant weed management plan will require the integration of multiple herbicide chemistries in an effort to lessen selection pressure and delay the occurrence of herbicide resistance in a field. Other control strategies, such as tillage, extreme cover crops, narrow row spacing, hand-weeding, crop rotation, and mechanical cultivation must also be included in an herbicide resistant weed management plan (Table 1). The herbicide recommendations in Tables 2-6 are aimed at preserving the herbicide tools that are available for weed management. For additional information about herbicide resistant weeds, visit the UGA Weed Science Web-Page at the following web address:

<http://www.gaweed.com/resistance.html>

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**Table 1. Non-Chemical Control Strategies for the Management of Herbicide-Resistant Palmer Amaranth\*.**

Strategy	Effect
Tillage (moldboard plow)	Burying Palmer amaranth seed at least 4” deep in the soil will provide approximately 50% control of Palmer amaranth.
Extreme Rye Cover Crops	A well-managed rye cover crop, planted in the fall, terminated at its maximum height, and rolled will form a dense mat of residue which will provide approximately 60-90% control of Palmer amaranth.
Decreased row widths	Decreasing row widths results in faster canopy closure and shade formation. Palmer amaranth seed requires light for germination.
Hand-Weeding	Hand-removal of escaped female Palmer amaranth plants before seed production will prevent further seed-rain into a field.
Crop Rotation	Crop rotations that include field corn provide growers with an opportunity to use alternative herbicide modes of action and also provide for additional time in the fall for seed-bank management.
Mechanical Cultivation	No weeds are steel-resistant.

\*An aggressive combination of non-chemical and chemical control tactics will be required to manage herbicide-resistant Palmer amaranth.

**Table 2. Herbicide Programs for Managing Glyphosate and ALS-Resistant Palmer Amaranth in Field Corn.<sup>1</sup>**

Corn Hybrid	Preemergence	Postemergence	Layby as needed
<b>Conventional</b>	Atrazine**	Prowl <sup>2</sup> + Atrazine + Crop Oil	2,4-D <sup>5</sup> or Banvel/Clarity <sup>4,5</sup> or Status <sup>10</sup>
	Atrazine**	Atrazine + 1 of the following: Callisto, Laudis, Capreno, Steadfast Q	2,4-D <sup>5</sup> or Banvel/Clarity <sup>4,5</sup> or Status <sup>10</sup>
	Dual II Magnum <sup>6</sup> or Micro-Tech or Zidua	Atrazine + 1 of the following: Callisto, Laudis, Capreno, Steadfast Q	2,4-D <sup>5</sup> or Evik or Banvel/Clarity <sup>4,5</sup> or Status <sup>10</sup>
<b>Liberty-Link</b>	Atrazine**	Liberty + atrazine <sup>7</sup>	2,4-D <sup>5</sup> or Banvel/Clarity <sup>4,5</sup> or Status <sup>10</sup>
	Dual II Magnum <sup>6</sup> or Micro-Tech or Zidua	Liberty + atrazine <sup>7</sup>	2,4-D <sup>5</sup> or Evik or Banvel/Clarity <sup>4,5</sup> or Status <sup>10</sup>
<b>Roundup Ready</b>	Atrazine**	glyphosate + atrazine or glyphosate + Warrant or glyphosate + Dual Magnum <sup>6</sup> or glyphosate + Status <sup>10</sup> or Expert <sup>8</sup> or Sequence <sup>9</sup> or Halex GT <sup>11</sup>	2,4-D <sup>5</sup> or Banvel/Clarity <sup>4,5</sup> or Status <sup>10</sup>
	Dual II Magnum <sup>6</sup> or Micro-Tech or Zidua	glyphosate + atrazine or glyphosate + Status <sup>10</sup> or Expert <sup>8</sup> or Halex GT	2,4-D <sup>5</sup> or Banvel/Clarity <sup>4,5</sup> or Status <sup>10</sup>

<sup>1</sup>Glyphosate- and ALS-resistant Palmer amaranth are very serious concerns. An aggressive management program is necessary to slow spread of resistant biotypes and to reduce selection pressure in areas currently not infested with resistant biotypes.

<sup>2</sup>Generic brands of Prowl (pendimethalin) are available and perform similarly.

<sup>3</sup>Bicep II Magnum is a pre-mixture of S-metolachlor and atrazine. Less expensive, generic brands containing metolachlor and atrazine are available (Parallel Plus, Stalwart Xtra). These generic brands may not provide the same length of residual control as Bicep II Magnum (which contains S-metolachlor).

<sup>4</sup>Generic brands of Banvel (dicamba dimethylamine salt) are available and perform similarly.

<sup>5</sup>Use extreme caution to avoid drift to sensitive crops, such as cotton, tobacco, soybeans, and vegetables. Use only amine formulations of 2,4-D. Follow all label directions for drift management.

<sup>6</sup>Generic brands containing metolachlor are available (Me-Too-Lachlor-II, Parallel, Stalwart-C). However, these generic brands may not provide the same length of residual control as Dual II Magnum (S-metolachlor).

<sup>7</sup>Also available in a pre-mixture sold under the trade name of Liberty ATZ.

<sup>8</sup>Expert is a pre-mixture of glyphosate + S-metolachlor + atrazine.

<sup>9</sup>Sequence is a pre-mixture of glyphosate + S-metolachlor.

<sup>10</sup>Status is a pre-mixture of dicamba + diflufenzopyr + isoxadifen.

<sup>11</sup>Halex GT is a pre-mixture of glyphosate + S-metolachlor + mesotrione

**\*\* When atrazine is applied PRE + POST, a total of 2.5 lb ai/A can be applied per year (2.5 qt/A of 4L or 44**

oz/A of 90DF). When atrazine is applied only POST, then a total of 2.0 lb ai/A can be applied per year (2 qt/A of 4L or 36 oz/A of 90DF).

**SPECIAL NOTE: Dual Magnum, Micro-Tech, Warrant, and Zidua have the same mode of action (inhibit very long chain fatty acids). Multiple applications of these herbicides in a single year should be avoided to prevent or delay the evolution of resistance. These herbicides have no postemergence activity.**

**Table 3. Herbicides Programs for Managing Glyphosate, ALS, and Atrazine Resistant Palmer Amaranth in Field Corn.**

Hybrid	Preemergence	Postemergence <sup>1</sup>
Any	Dual II Magnum or MicroTech or Zidua	Callisto <sup>2</sup> , Capreno, Impact, Armezon, Laudis, Realm Q, or Status
Liberty-Link	Dual II Magnum or MicroTech or Zidua	Liberty

<sup>1</sup>Atrazine can be tank-mixed with these herbicides if other weeds are a concern such as sicklepod and morningglory.

<sup>2</sup>Callisto Xtra is a pre-mixed formulation of Callisto + Atrazine.

### POST-HARVEST (CORN) MANAGEMENT OF PALMER AMARANTH

After corn harvest, Palmer amaranth plants that emerge up until 35 days before first frost will have the potential to produce viable seed. Consequently, these post-harvest populations should be managed up until this time using 1 or more of the following strategies:

a) For plants larger than 6” in height:

- 1) Mowing
- 2) Tillage

b) For plants less than 6” in height:

- 1) Tillage or
- 2) Gramoxone SL @ 48 oz/A or Firestorm/Parazone 3SL @ 32 oz/A + 2,4-D **amine** 3.8SC @ 16-24 oz/A + COC (1.0% v/v). If cotton is nearby and drift is a concern, consider using Clarity 4SL @ 8 oz/A instead of 2,4-D. Delay planting of small grains for at least 10 days for each 16 oz/A of 2,4-D applied or 15 days for each 8 oz/A of Clarity applied.
- 3) If residual control is desired and a small grain will **not** be planted in the fall, Dual Magnum/ Stalwart, etc. @ 1 pt/A can be included with the burndown treatment.

It is important to remember that viable Palmer amaranth seed can be produced within 2 weeks after pollen shed. Thus, control strategies need to be implemented before this time to be effective in reducing weed-seed rain back into a field.

**Table 4. Herbicide Programs for Managing Palmer Amaranth in Grain Sorghum.**

Preemergence <sup>1</sup>	Postemergence <sup>2</sup> (over the top)	Postemergence <sup>3</sup> (Directed Spray)	Hooded Sprayer
Dual Magnum or Intro/MicroTech or Warrant	Atrazine	2,4-D or Clarity	Gramoxone SL or Firestorm or Parazone

<sup>1</sup>Must use Concep treated seed. <sup>2</sup>3-leaf sorghum up until 12” in height. <sup>3</sup>8-15” tall sorghum.

**Table 5. Herbicide Programs for Managing ALS-Resistant Palmer Amaranth in Peanut.<sup>1</sup>**

Preplant Incorporated	Preemergence <sup>2</sup>	Cracking or early postemergence <sup>3</sup> (Palmer < 3 in.)	Postemergence <sup>4</sup> (Palmer < 3 in.)
Prowl <sup>5</sup> or Sonalan	Valor or Spartan Charge <sup>6,7</sup>		Cobra <sup>7</sup> or Ultra Blazer <sup>7,8,9</sup> + 2,4-DB
Prowl <sup>5</sup> or Sonalan		Gramoxone SL or Firestorm or Parazone + Storm + Dual Magnum <sup>9</sup>	Cobra <sup>7</sup> or Ultra Blazer <sup>7</sup> + Dual Magnum <sup>9</sup>

<sup>1</sup>ALS-resistant Palmer amaranth is a very serious concern. An aggressive management program is necessary to slow spread of the resistant biotypes and to reduce selection pressure in areas currently not infested with resistant biotypes. A combination of soil residual and postemergence herbicides will be required for optimum control.

<sup>2</sup>Strongarm is not included in this table because it is an ALS-inhibiting herbicide. However, it can be used for the control of other broadleaf weeds. If Strongarm is used preemergence, Cadre or Pursuit should **NOT** be applied postemergence.

<sup>3</sup>Apply cracking or early postemergence treatment only if weeds have emerged.

<sup>4</sup>Cadre or Pursuit may be tank-mixed with Cobra or Ultra Blazer if needed for control of other weed species. Cadre and Pursuit are ALS- inhibitors. Because of concerns with weed resistance to ALS-inhibitors, a mixture of Cobra or Ultra Blazer with Cadre or Pursuit would be preferred over Cadre or Pursuit alone. When using Cadre or Pursuit, follow all labeled crop rotation restrictions.

<sup>5</sup>Generic brands of Prowl (pendimethalin) are available and perform similarly. Prowl or Sonalan can be used preemergence if 0.5-0.75" of water can be applied within 48 hours of application. They can be tank-mixed with Valor or Spartan Charge in this situation.

<sup>6</sup>If Valor or Spartan Charge is properly activated with 0.5-0.75" of rainfall or irrigation within 7 days of application, it is unlikely that an "at-cracking" treatment will be required. However, if control with Valor or Spartan Charge is unacceptable, an "at-cracking" treatment of Gramoxone Inteon or Firestorm or Parazone + Storm + Dual Magnum should be applied.

<sup>7</sup>Valor, Cobra, Spartan Charge, Storm, and Ultra Blazer have the same mode of action (PPO inhibitor). Consequently, no more than 2 applications of these herbicides should be used in a season.

<sup>8</sup>Dual Magnum can be tank-mixed with Cobra or Ultra Blazer if additional residual control is needed in these programs. However, a three-way tank-mix of Cobra or Ultra Blazer + Dual Magnum + 2,4-DB is **not** recommended.

<sup>9</sup>Generic brands of metolachlor are available (Stalwart, Parallel PCS, Me-Too-Lachlor). However, these generic brands have not provided the same length of residual control as Dual Magnum (*S*-metolachlor) in some UGA field trials. When tank-mixing paraquat, Cobra or Ultra Blazer with Dual Magnum/generics, additional spray adjuvants (NIS, COC) are not recommended and will likely increase peanut injury.

**Table 6. Herbicide Programs for Managing Glyphosate/ALS-Resistant Palmer Amaranth and Delaying PPO/LCFA Resistance in Soybeans.<sup>1</sup>**

Soybean Variety	Program	Preemergence <sup>2</sup>	Postemergence <sup>3,4</sup>
<b>Roundup Ready</b>	1	TriCor/Metribuzin; or Canopy/Cloak <sup>5</sup> ; or Authority MTZ <sup>7,13</sup> ; or Authority XL <sup>7,14</sup>	glyphosate + Reflex <sup>7</sup> ; or glyphosate + Prefix <sup>7,8</sup> ; or glyphosate + Warrant <sup>15</sup> ; or glyphosate + Dual Magnum <sup>15</sup> ; or Sequence <sup>9</sup> ; or Flexstar GT <sup>7,10</sup>
	2	Boundary <sup>6</sup>	glyphosate + Reflex <sup>7</sup> ; or Flexstar GT <sup>7,10</sup>
	3	Prowl; or Dual Magnum <sup>15</sup> ; or Intro <sup>15</sup> ; or Warrant <sup>15</sup>	glyphosate + Reflex <sup>7</sup> ; or Flexstar GT <sup>7,10</sup>
	4	Reflex; or Valor; or Envive <sup>7,11</sup> ; or Valor XLT <sup>7,12</sup>	glyphosate + Warrant <sup>15</sup> ; or glyphosate + Dual Magnum <sup>15</sup> ; or Sequence <sup>9</sup>
<b>Liberty-Link</b>	1	Prowl; or Dual Magnum <sup>15</sup> ; or Intro <sup>15</sup> ; or Warrant <sup>15</sup>	Liberty + Reflex <sup>7</sup>
	2	Reflex; or Valor; or Envive <sup>7,11</sup> ; or Valor XLT <sup>7,12</sup>	Liberty + Dual Magnum <sup>15</sup> or Warrant <sup>15</sup>
<b>Conventional</b>	1	TriCor/Metribuzin; or Canopy/Cloak <sup>5</sup> ; or Authority MTZ <sup>7,13</sup> ; or Authority XL <sup>14</sup> + Prowl	Reflex <sup>7</sup> ; or Ultra Blazer <sup>7</sup> + Dual Magnum <sup>15</sup> or Warrant <sup>15</sup> ; or Cobra <sup>7</sup> + Dual Magnum <sup>15</sup> or Warrant <sup>15</sup> ; or Prefix <sup>7,8</sup>
	2	Boundary <sup>6</sup>	Reflex <sup>7</sup>
	3	Prowl; or Dual Magnum <sup>15</sup> ; or Intro <sup>15</sup> ; or Warrant <sup>15</sup>	Reflex <sup>7</sup>

<sup>1</sup>Glyphosate- and ALS-resistant Palmer amaranth are very serious concerns. An aggressive management program is necessary to slow spread of resistant biotypes and to reduce selection pressure in areas currently not infested with resistant biotypes.

<sup>2</sup>Generic brands of Prowl (pendimethalin) are available and perform similarly. When using Authority MTZ, Boundary, TriCor/Metribuzin or Canopy, follow label for appropriate rates, soil pH restrictions, and soybean variety tolerance. Dryland growers should consider mechanically incorporating Authority MTZ, Metribuzin, Canopy, Boundary, and Prowl. If mechanically incorporating herbicides, Treflan can be used instead of Prowl if preferred.

<sup>3</sup>**Postemergence applications **MUST** be made before the largest Palmer amaranth plant in the field exceeds 2-3" in height. If a preemergence herbicide is used but not moisture activated, this could occur as early as 10-14 days after planting depending upon the time of year. Palmer amaranth plants can grow from 1-3" per day.** When applied in combination with glyphosate, use either 16-24 oz/A of Reflex, 24 oz/A of Ultra Blazer, or 12.5 oz/A of Cobra.

<sup>4</sup>If residual herbicides are activated by a timely rainfall or irrigation event, a second postemergence application may not be needed. The total amounts of these herbicides that can be applied per acre per year are as follows: Cobra - 25 oz/A; Reflex - 24 oz/A; and Ultra Blazer - 32 oz/A. Reflex may be preferred because of residual control of Palmer amaranth. On Roundup Ready soybean, glyphosate can be included in the second application if needed for the control of other weeds.

<sup>5</sup>Canopy/Cloak is a pre-mixture of metribuzin + chlorimuron (Classic).

<sup>6</sup>Boundary is a pre-mixture of metribuzin and S-metolachlor (Dual Magnum).

<sup>7</sup>Authority MTZ, Authority XL, Cobra, Envive, Flexstar GT, Prefix, Reflex, Ultra Blazer, Valor, Valor XLT have the

same mode of action (PPO inhibitor). More than 1 application of these herbicides in a single season should be avoided if at all possible to prevent/delay the development of PPO resistance.

<sup>8</sup>Prefix is a pre-mixture of fomesafen (Reflex) and S-metolachlor (Dual Magnum).

<sup>9</sup>Sequence is a pre-mixture of glyphosate and S-metolachlor (Dual Magnum). **Sequence will not control emerged glyphosate resistant pigweed.**

<sup>10</sup>Flexstar GT is a pre-mixture of fomesafen (Reflex) and glyphosate (Touchdown).

<sup>11</sup>Envive is a pre-mixture of chlorimuron (Classic), flumioxazin (Valor) and thifensulfuron (Harmony).

<sup>12</sup>Valor XLT is a pre-mixture of flumioxazin (Valor) and chlorimuron (Classic).

<sup>13</sup>Authority MTZ is a pre-mixture of sulfentrazone (Spartan) and metribuzin.

<sup>14</sup>Authority XL is a pre-mixture of sulfentrazone (Spartan) and chlorimuron (Classic).

<sup>15</sup>Dual Magnum, Intro, and Warrant are members of the same herbicide family (chloroacetamide) and have the same mode of action (inhibit very long chain fatty acids). Multiple applications of these herbicides in a single year should be avoided to prevent or delay the evolution of resistance. These herbicides have no postemergence activity.

### **SOYBEAN VARIETY TOLERANCE TO METRIBUZIN HERBICIDES**

**Soybean varieties that have exhibited acceptable tolerance to metribuzin herbicides (Boundary, Canopy, TriCor) in UGA tests conducted in 2008-2012 include the following:**

**Group IV:** Asgrow 4903 RR/STS, Southern States RT4808

**Group V:** Asgrow 5905RR, AGS 568RR, Delta Pineland DP5634, Pioneer 95Y20, Pioneer 95Y40, Pioneer 95Y50, Pioneer 95Y70, Southern States RT5951NRR, Southern States RT5960NRR, Pioneer 95Y61, Pioneer 95Y71, Pioneer 95Y80

**Group VI:** Asgrow 6301RR, Delta Pineland DP6568, Pioneer 96M60, Southern States RT 6451NRR, Vigoro V61N9

**Group VII:** AGS 758RR, Asgrow 7501RR, Asgrow H7242, Benning, Northrup King NKS 76L9, Northrup King NKS 78G6, Pioneer 97M50, Southern States RT7270NRR, USG 7732nRR, Vigoro V74N9, Woodruff

**Group VIII:** Northrup King NKS 80P2, Prichard RR

**\*\* Soybean varieties not included in this list have not been adequately evaluated.**

**\*\*Rates tested in these studies include the following: Boundary 6.5EC @ 24 oz/A; Canopy 75DG @ 6 oz/A; Metribuzin 75DG @ 5.3 oz/A.**

**\*\* Metribuzin herbicides are NOT recommended for use on sands or other coarse soils with less than 1% OM.**

**\*\*\*METRIBUZIN HERBICIDE SHOULD NOT BE USED ON THE FOLLOWING SOYBEAN VARIETIES: Southern States LL511N and LL595N; AG6730; AG6130**

**Table 7. Soybean Pre-Mixtures and Equivalent Rates**

<b>Pre-Mixture</b>	<b>Rate/A</b>	<b>Equivalent Rates/A</b>
Authority MTZ 45DG	14 oz/A	Spartan 4L @ 5.04 oz TriCor 75DG @ 5.04 oz
Boundary 6.5EC	1.5 pt	Dual Magnum 7.62EC @ 16.5 oz TriCor 75DF @ 4.9 oz
Canopy 75DG	6 oz	TriCor 75DG @ 5.1 oz Classic 25DG @ 2.6 oz
Envive 41.3DG	2.5 oz	Valor 51WG @ 1.44 oz Classic 25DG @ 0.90 oz Harmony 75DG @ 0.14 oz
Flexstar GT 3.5 2.82SL	3.5 pt	Touchdown Total 4.17SL @ 30.4 oz Reflex 2SL @ 15.7 oz
Prefix 5.29SL	2.33 pt	Dual Magnum 7.62EC @ 21.2 oz Reflex 2SL @ 17.7 oz
Sequence 5.25SL	3 pt	Dual Magnum 7.62EC @ 18.9 oz Touchdown Total 4.17SL @ 25.9 oz
Valor XLT 40.3DG	4 oz	Valor 51WG @ 2.35 oz Classic 25DG @ 1.65 oz