



Managing Herbicide-Resistant Palmer Amaranth In Field Corn, Grain Sorghum, Peanut, and Soybean - 2016

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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, contact your local county extension agent and visit the UGA Weed Science Web-Page at the following web address: <http://www.gaweed.com/resistance.html>

***Updated: January 11, 2016
This version supersedes all previous versions.***

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.¹

Corn Hybrid	Preemergence	Postemergence	Layby/Directed if needed
Conventional	Atrazine**	Prowl ² + Atrazine + Crop Oil	2,4-D ⁵ or Banvel/Clarity ^{4,5} or Status ¹⁰
	Atrazine**	Atrazine + 1 of the following: Callisto, Laudis, Capreno, Steadfast Q	2,4-D ⁵ or Banvel/Clarity ^{4,5} or Status ¹⁰
	Dual II Magnum ⁶ or Warrant or Zidua or Anthem ¹²	Atrazine + 1 of the following: Callisto, Laudis, Capreno, Steadfast Q	2,4-D ⁵ or Evik or Banvel/Clarity ^{4,5} or Status ¹⁰
Liberty-Link	Atrazine**	Liberty ¹³ + atrazine ⁷	2,4-D ⁵ or Banvel/Clarity ^{4,5} or Status ¹⁰
	Dual II Magnum ⁶ or Warrant or Zidua or Anthem ¹²	Liberty ¹³ + atrazine ⁷	2,4-D ⁵ or Evik or Banvel/Clarity ^{4,5} or Status ¹⁰
Roundup Ready	Atrazine**	glyphosate + atrazine; or glyphosate + Warrant; or glyphosate + Dual Magnum ⁶ ; or glyphosate + Status ¹⁰ ; or Expert ⁸ ; or Sequence ⁹ ; or Halex GT ¹¹	2,4-D ⁵ or Banvel/Clarity ^{4,5} or Status ¹⁰
	Dual II Magnum ⁶ or Warrant or Zidua or Anthem ¹²	glyphosate + atrazine; or glyphosate + Status ¹⁰ ; or Expert ⁸ ; or Halex GT	2,4-D ⁵ or Evik or Banvel/Clarity ^{4,5} or Status ¹⁰

¹ 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.

² Generic brands of Prowl (pendimethalin) are available and perform similarly.

³ 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).

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

⁵ 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.

⁶ 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).

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

⁸ Expert is a pre-mixture of glyphosate + S-metolachlor + atrazine.

⁹ Sequence is a pre-mixture of glyphosate + S-metolachlor.

¹⁰ Status is a pre-mixture of dicamba + diflufenzopyr + isoxadifen (safener).

¹¹Halex GT is a pre-mixture of glyphosate + S-metolachlor + mesotrione

¹²Anthem is a pre-mixture of pyroxasulfone + fluthiacet.

¹³Generic formulations of glufosinate are also available including Kong and Interline. Generic formulations of glufosinate should be used with caution because limited data has been collected by UGA.

**** 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: Anthem, Dual Magnum, Warrant, and Zidua have the same mode of action (inhibit very long chain fatty acids). Multiple applications (> 2) 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 ¹
Any	Dual II Magnum or Warrant or Zidua or Anthem	Callisto ² , Capreno, Impact, Armezon, Laudis, Realm Q, or Status
Liberty-Link	Dual II Magnum or Warrant or Zidua or Anthem	Liberty ³

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

²Callisto Xtra is a pre-mixed formulation of Callisto + Atrazine.

³Generic formulations of glufosinate are also available including Kong and Interline. Generic formulations of glufosinate should be used with caution because limited data has been collected by UGA.

POST-HARVEST (FIELD CORN) MANAGEMENT OF PALMER AMARANTH

After field 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/Helmquat 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.
- 4) In dairy situations (*i.e. no rotations with peanuts, soybeans, and cotton: no overuse of PPO herbicides*), Valor 51WG (2 oz/A) can be used for the residual control of Palmer amaranth after field corn harvest. Wheat can be planted 30 days after application (*need 1" rainfall/irrigation after application*), cereal rye and barley can be planted 3 months after application, and ryegrass can be planted 4 months after application (with tillage). Valor can be tank-mixed with paraquat.

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 ¹	Postemergence ² (over the top)	Postemergence ³ (Directed Spray)	Hooded Sprayer
Dual Magnum or Warrant	Atrazine or Huskie + Atrazine	2,4-D or Clarity	Gramoxone SL or Firestorm or Parazone or Helmquat

¹Must use Concep treated seed. ²3-leaf sorghum up until 12" in height. ³8-15" tall sorghum.

Table 5. Herbicide Programs for Managing ALS-Resistant Palmer Amaranth in Peanut.¹

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

¹ALS-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.

²Strongarm 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.

³Apply cracking or early postemergence treatment only if weeds have emerged.

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

⁵Generic 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.

⁶If 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 or Warrant should be applied.

⁷Valor, 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.

⁸Generic 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. When using Warrant with POST application, add NIS.

⁹Generic formulations of Valor 51WG (flumioxazin) are also available including Outflank, Panther, and Rowel. Panther SC is a liquid formulation of flumioxazin but this formulation has not yet been adequately tested by UGA weed scientists.

SPECIAL NOTE: Dual Magnum and Warrant are in the same herbicide family and have the same mode of action (inhibit very long chain fatty acids). Multiple applications (> 2) 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 6. Herbicide Programs for Managing Glyphosate/ALS-Resistant Palmer Amaranth and Delaying PPO/VLCFA Resistance in Soybeans.¹

Soybean Variety	Program	Preemergence ²	Postemergence ^{3,4}
Roundup Ready	1	TriCor/Metribuzin; or Canopy/Cloak ⁵ ; or Authority MTZ ^{7,13}	glyphosate + Reflex ^{7,20} ; or glyphosate + Prefix ^{7,8} or Warrant Ultra ¹⁷ ; or Flexstar GT ^{7,10}
	2	Boundary ⁶	glyphosate + Reflex ^{7,20} ; or Flexstar GT ^{7,10}
	3	Prowl; or Dual Magnum ¹⁵ ; or Warrant ¹⁵ or Zidua ¹⁵ or Anthem ^{15,17}	glyphosate + Reflex ^{7,20} ; or Flexstar GT ^{7,10}
	4	Valor; or Envive ^{7,11} ; or Authority XL ^{7,14} ; or Fierce ^{7,16}	glyphosate + Warrant ¹⁵ ; or glyphosate + Dual Magnum ¹⁵ ; or glyphosate + Zidua ¹⁵ ; or Sequence ⁹
Liberty-Link	1	Prowl; or Dual Magnum ¹⁵ ; or Warrant ¹⁵ ; or Zidua ¹⁵ or Anthem ^{15,17}	Liberty ¹⁹ + Reflex ^{7,20}
	2	Valor; or Envive ^{7,11} ; or Authority XL ^{7,14} ; or Fierce ^{7,16}	Liberty ¹⁹ + Dual Magnum ¹⁵ or Warrant ¹⁵ or Zidua ¹⁵ or Anthem ^{15,17}
Conventional	1	TriCor/Metribuzin; or Canopy/Cloak ⁵ ; or Authority MTZ ^{7,13} <i>(include Prowl for grass control)</i>	Reflex ^{7,20} ; or Ultra Blazer ⁷ + Dual Magnum ¹⁵ or Warrant ¹⁵ ; or Cobra ⁷ + Dual Magnum ¹⁵ or Warrant ¹⁵ ; or Prefix ^{7,8} or Warrant Ultra ¹⁷
	2	Boundary ⁶	Reflex ^{7,20}
	3	Prowl; or Dual Magnum ¹⁵ ; or Warrant ¹⁵ ; or Zidua ¹⁵ or Anthem ^{15,17}	Reflex ^{7,20}

¹Glyphosate- 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.

²Generic 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. If Envive or Authority XL are used, consider planting an STS/ST soybean variety to help minimize potential early-season Classic injury caused by cool, wet weather.

³**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.

⁴If 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.

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

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

⁷Authority MTZ, Authority XL, Cobra, Envive, Flexstar GT, Prefix, Reflex, Ultra Blazer, Valor, Valor XLT, and Fierce 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.

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

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

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

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

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

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

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

¹⁵Dual Magnum 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 (>2) of these herbicides in a single year should be avoided to prevent or delay the evolution of resistance. Anthem and Zidua are not in the same herbicide family as Dual or Warrant but do have the same mode of action. These herbicides have no postemergence activity except Anthem.

¹⁶Fierce is a pre-mixture of flumioxazin (Valor) and pyroxasulfone (Zidua)

¹⁷Anthem is a pre-mixture of pyroxasulfone (Zidua) + fluthiacet (Cadet).

¹⁸Warrant Ultra is a pre-mixture of fomesafen (Reflex) and acetochlor (Warrant)

¹⁹Generic formulations of glufosinate are also available including Cheetah, Kong, and Interline. Cheetah Max is a combination of glufosinate + fomesafen. Generic formulations of glufosinate should be used with caution because limited data has been collected by UGA.

²⁰Generic formulations of Reflex 2SL (fomesafen) are also available including Dawn and TopGun. Sinister contains 2.87 lb ai/gal of fomesafen.

SOYBEAN VARIETY TOLERANCE TO METRIBUZIN HERBICIDES

Soybean varieties that have exhibited acceptable tolerance to metribuzin herbicides (Boundary, Canopy, TriCor) in UGA tests conducted in 2008-2014 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, Pioneer P54T94R

Group VI: Asgrow 6301RR, Delta Pineland DP6568, Pioneer 96M60, Southern States RT 6451NRR, Vigoro V61N9, Northrup King NK-67R6

Group VII: AGS 758RR, Asgrow 7501RR, Asgrow H7242, Benning, Northrup King NKS 76L9, Northrup King NK-74M3, Northrup King NK-77T7, Northrup King NK-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 by UGA.**

****Rates tested in these studies include the following: Boundary 6.5EC @ 24 oz/A; Canopy 75DG @ 6 oz/A; Tricor/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: AGS LL5911, Southern States LL511N and LL595N; AG6730; AG6130**