

MANAGING GLYPHOSATE-RESISTANT PALMER AMARANTH IN ROUNDUP READY SOYBEANS

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Introduction

Glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) was confirmed in Macon County, Georgia in 2005 (Culpepper et al, 2006). Initially, GR-Palmer amaranth was confirmed on 500 acres in Macon County in 2005 (Culpepper and Brown, 2006). Since 2005, this pest has spread very quickly across Georgia. As of May 2008, 20 Georgia counties have confirmed GR-Palmer amaranth populations. (Culpepper, 2008). Palmer amaranth can grow one to two inches a day and a single female can produce 500,000 seeds making this pest hard to control with postemergence herbicides (Culpepper et al, 2007).

In 2005, it has been estimated that 87 percent of the soybeans planted in the U.S. were herbicide tolerant varieties. Growers have reduced the use of residual herbicides in herbicide tolerant crops and have depended more on postemergence herbicides for weed control. Weed management programs recommended to control glyphosate-resistant Palmer amaranth depends on the activation of residual herbicides and timely postemergence herbicide applications. Dryland producers struggle getting residual herbicides activated making Palmer amaranth management difficult.

Materials and Methods

Two field trials were conducted in 2006 in Macon County, Georgia to evaluate herbicide systems to control glyphosate-resistant (GR) Palmer amaranth in soybeans. The soybeans were planted in 36 inch rows on May 3, 2006 with an air planter. The plot size was 2 rows by 25 feet long. All herbicide treatments were applied with a CO₂ powered backpack sprayer calibrated to deliver 15 GPA with 11002DG flat fan nozzle tips. Rainfall (1.5 inches) occurred 3 days after the preemergence herbicides were applied. Traditional small plot techniques were used and all treatments were replicated 4 times.

Test one evaluated 14 herbicide treatments to control glyphosate-resistant Palmer amaranth in soybeans. The treatments consisted of combinations of preemergence and/or postemergence herbicides in order to develop herbicide systems for GR Palmer amaranth control. The preemergence herbicides included Boundary® (s-metolachlor + metribuzin)¹, Canopy® (metribuzin + chlorimuron ethyl)², First Rate™ (cloransulam-methyl)³, Intro® (alachlor)⁴, Prowl® H2O (pendimethalin)⁵, and Valor™ (flumioxazin)⁶. The postemergence herbicides included Cobra® (lactofen)⁷, Flexstar® (fomesafen)⁸, Fusion® (fluazifop-P-butyl + fenoxaprop-P-ethyl)⁹, Roundup WeatherMax® (glyphosate)¹⁰, and Select® (clethodim)¹¹. The postemergence herbicides were applied at 3 different timings which included early postemergence (0.5 inch Palmer amaranth), mid postemergence (2 to 5 inch Palmer amaranth), and late postemergence (up to 12 inch Palmer amaranth). The herbicide treatments are shown in

Table 1.

Table 1. Herbicide Treatments and Timing, GR Palmer Amaranth Test 1, Macon County, GA, 2006

Treatment	Herbicide Timings			
	PRE	EPOST	MPOST	LPOST
A			Roundup WeatherMax 22 oz/A + AMS 2% v/v	Roundup WeatherMax 22 oz/A + AMS 2% v/v
B		Roundup WeatherMax 22 oz/A + Flexstar 12 oz/A + AMS 2% v/v		
C	Intrro 2 qt/A		Roundup WeatherMax 22 oz/A + AMS 2% v/v	
D	Intrro 2 qt/A		Roundup WeatherMax 22 oz/A + Flexstar 12 oz/A + AMS 2% v/v	
E	Intrro 2 qt/A	Flexstar 20 oz/A + Fusion 10oz/A + NIS 0.5% v/v		
F	Intrro 2 qt/A + Valor 2 oz/A		Roundup WeatherMax 22 oz/A + AMS 2% v/v	
G	Valor 2 oz/A		Roundup WeatherMax 22 oz/A + AMS 2% v/v	
H	Valor 2 oz/A	Cobra 12 oz/A + Select 6 oz/A + COC 0.5% v/v		
I	Valor 2 oz/A + FirstRate 0.4 oz/A		Roundup WeatherMax 22 oz/A + AMS 2% v/v	
J	Prowl H20 1 qt/A		Roundup WeatherMax 22 oz/A + AMS 2% v/v	
K	Prowl H20 1 qt/A	Raptor 4 oz/A + Ultra Blazer 10 oz/A + COC 1% v/v		
L	Canopy 4 oz/A		Roundup WeatherMax 22 oz/A + AMS 2% v/v	
M	Boundary 34 oz/A	Flexstar 20 oz/A + Fusion 10 oz/A + NIS 0.5 v/v		
Untreated				

PRE = May 4; EPOST = May 24, 0.5" tall pigweed; MPOST = May 31, 2-5" tall pigweed; LPOST = June 22, up to 12" tall pigweed.

Test two evaluated 12 treatments for glyphosate-resistant Palmer amaranth control in soybeans. The herbicide treatments consisted of preemergence and postemergence herbicide combinations. Preemergence herbicides included Valor, Sencor® (metribuzin)¹² + Prowl H2O, Dual Magnum® (s-metolachlor)¹³, Parallel™ PCS (metolachlor)¹⁴ and Stalwart® (metolachlor)¹⁵. The postemergence herbicides included Roundup WeatherMax tankmixed with Cobra, Reflex® (fomesafen) or Ultra Blazer® (acifluorfen). The Palmer amaranth was 2 to 5

inches tall when postemergence herbicides were applied. The herbicide treatments are shown in Table 2.

Table 2. Herbicide Treatments and Timing, GR Palmer Amaranth Test 2, Macon County, GA, 2006

Treatment	Herbicide, Rate and Timing	
	PRE	POST
Untreated		
A	Valor 2 oz/A	Roundup WeatherMax 22 oz/A
B	Valor 2 oz/A	Roundup WeatherMax 22 oz/A + Cobra 8 oz/A
C	Valor 2 oz/A	Roundup WeatherMax 22 oz/A + Cobra 12.5 oz/A
D		Roundup WeatherMax 22 oz/A + Cobra 8 oz/A
E		Roundup WeatherMax 22 oz/A + Cobra 12.5 oz/A
F		Roundup WeatherMax 22 oz/A + Reflex 16 oz/A
G		Roundup WeatherMax 22 oz/A + Ultra Blazer 16 oz/A
H	Sencor 8 oz/A + Prowl H2O 1 qt/A	
I	Dual Magnum 16 oz/A	
J	Parallel PCS 16 oz/A	
K	Stalwart 16 oz/A	

^aPRE = May 4; POST = May 31, 2-5" tall pigweed.

Herbicide treatments in both tests were rated for Palmer amaranth control at 21, 39, 53 and 83 days after treatment (DAT). Palmer amaranth control ratings were obtained using a visual scale of 0 to 100 percent (0 = no control, 100 = complete control). The data were subjected to ANOVA and means separated using Duncan's Multiple Range Test (P = 0.10). Crop injury ratings and yield data were not obtained due to severe deer damage.

Results

Results from Test 1 are shown in Table 3. Treatments E, K, and M provided greater than 93 percent control at 83 DAT. Treatments D, H and I provided 88, 85 and 76 percent control, respectively. These treatments used residual herbicides to control Palmer amaranth emergence. Treatment A, which consisted of 2 postemergence applications of Roundup WeatherMax, was the least effective treatment in Test 1. This treatment consisted of no residual herbicides and the 2 postemergence applications of glyphosate do not control the glyphosate resistant Palmer amaranth population.

Results from Test 2 are shown in Table 4. Valor provided excellent residual control of glyphosate-resistant Palmer amaranth for at least 7 weeks after application. Treatments D, E, F and G were not effective in controlling glyphosate-resistant Palmer amaranth with less than 70 percent control throughout the season. Treatment H provided good control of glyphosate-resistant Palmer amaranth early but control was poor late in the season. No difference in glyphosate-resistant Palmer amaranth control was noted with Dual Magnum, Parallel PCS and Stalwart when applied at 1 pt/a and control was not acceptable late season (less than 50 percent control). Our results suggest that preemergence residual herbicides are going to be the foundation of any herbicide program designed to control glyphosate-resistant Palmer amaranth.

Table 3. GR-Palmer amaranth control in RR soybeans - I, Macon County – 2006.

Treatment	Herbicide	Rate/A	Timing ^a	Palmer Amaranth Control - %			
				May 24 ^b	June 8	June 22	July 25
A	Roundup WeatherMax + AMS	22 oz + 2% w/w	MPOST + LPOST	0 b	51 c	30 c	13 e
B	Roundup WeatherMax + Flexstar + AMS	22 oz + 12 oz + 2% w/w	EPOST EPOST EPOST	0 b	99 a	88 a	71 bc
C	Intrro Roundup WeatherMax + AMS	2 qt 22 ozs + 2% w/w	PRE MPOST MPOST	99 a	98 a	77 ab	51 cd
D	Intrro Roundup WeatherMax + Flexstar + AMS	2 qt 22 ozs + 12 oz + 2% w/w	PRE EPOST EPOST EPOST	99 a	99 a	98 a	88 ab
E	Intrro Flexstar + Fusion + NIS	2 qt 20 oz + 10 oz + 0.5% v/v	PRE EPOST EPOST EPOST	99 a	99 a	98 a	95 a
F	Intrro + Valor Roundup WeatherMax + AMS	2 qt + 2 oz 22 oz + 2% w/w	PRE PRE MPOST MPOST	99 a	99 a	93 a	69 bc
G	Valor Roundup WeatherMax + AMS	2 oz 22 oz + 2% w/w	PRE MPOST MPOST	99 a	98 a	97 a	70 bc
H	Valor Cobra + Select + COC	2 oz 12 oz + 6 oz + 0.5% v/v	PRE EPOST EPOST EPOST	99 a	99 a	98 a	85 ab
I	Valor + Firstrate Roundup WeatherMax + AMS	2 oz + 0.4 oz 22 oz + 2% w/w	PRE PRE MPOST MPOST	99 a	99 a	98 a	76 ab
J	Prowl H ₂ O Roundup WeatherMax + AMS	1 qt 22 oz + 2% w/w	PRE MPOST MPOST	99 a	78 b	65 a	38 d
K	Prowl H ₂ O Raptor + Ultra Blazer +	1 qt 4 oz + 10 oz +	PRE EPOST EPOST	99 a	99 a	98 a	94 a

	COC	1% v/v	EPOST				
L	Canopy Roundup WeatherMax + AMS	4 oz 22 oz + 2% w/w	PRE MPOST MPOST	99 a	99 a	96 a	40 d
M	Boundary Flexstar + Fusion + NIS	34 oz 20 oz + 10 oz + 0.5% v/v	PRE EPOST EPOST EPOST	99 a	99 a	98 a	93 a
Untreated		--	--	0 b	0 b	0 d	0 e

^aPRE = May 4; EPOST = May 24, 0.5" tall pigweed; MPOST = May 31, 2-5" tall pigweed; LPOST = June 22, up to 12" tall pigweed. ^bMeans in the same column with the same letter are not significantly different according to DMRT (P = 0.10).

Table 4. GR-Palmer amaranth control in Soybean - II, Macon County – 2006.

Treatment	Herbicide	Rate/A	Timing ^a	Palmer Amaranth Control - %			
				May 24 ^b	June 8	June 22	July 25
	Untreated	--	--	0 b	0 d	0 c	0 e
A	Valor Roundup WeatherMax	2 oz 22 oz	PRE POST	99 a	99 a	98 a	70 ab
B	Valor Roundup WeatherMax + Cobra	2 oz 22 oz + 8 oz	PRE POST POST	99 a	99 a	97 a	78 a
C	Valor Roundup WeatherMax + Cobra	2 oz 22 oz + 12.5 oz	PRE POST POST	99 a	99 a	98 a	80 a
D	Roundup WeatherMax + Cobra	22 oz + 8 oz	POST POST	0 b	56 c	46 b	23 de
E	Roundup WeatherMax + Cobra	22 oz + 12.5 oz	POST POST	0 b	56 c	46 b	26 cd
F	Roundup WeatherMax + Reflex	22 oz + 16 oz	POST POST	0 b	64 bc	50 b	33 cd
G	Roundup WeatherMax + Ultra Blazer	22 oz + 16 oz	POST POST	0 b	69 bc	50 b	20 de
H	Sencor + Prowl H ₂ O	8 oz + 1 qt	PRE PRE	99 a	80 b	61 b	50 bc
I	Dual Magnum	16 oz	PRE	96 a	71 bc	58 b	44 cd
J	Parallel PCS	16 oz	PRE	94 a	63 bc	44 b	30 cd
K	Stalwart	16 oz	PRE	93 a	71 bc	50 b	26 cd

^aPRE = May 4; POST = May 31, 2-5" tall pigweed.

^bMeans in the same column with the same letter are not significantly different according to DMRT (P = 0.10).

Sources of Materials

- ¹ Boundary®, s-metolachlor + metribuzin, Syngenta Crop Protection, Inc., P.O. Box 18300, Greensboro, NC 27419.
- ² Canopy®, metribuzin + chlorimuron ethyl, DuPont Crop Protection, Laurel Run Building, Chestnut Run Plaza, Wilmington, DE 19898.
- ³ First Rate™, cloransulam-methyl, Dow AgroSciences, LLC, 9330 Zionsville Road, Indianapolis, IN 46268.
- ⁴ Intrro®, alachlor, Monsanto Company, 800 North Lindbergh Blvd., St. Louis, MO 63167.
- ⁵ Prowl® H2O, pendimethalin, BASF Ag Products, P.O. Box 13528, 26 Davis Drive, Research Triangle Park, NC 27709-3528.
- ⁶ Valor™, flumioxazin, Valent U.S.A. Corporation Agricultural Products, P.O. Box 8025, Walnut Creek, CA 94596.
- ⁷ Cobra®, lactofen, Valent U.S.A. Corporation Agricultural Products, P.O. Box 8025, Walnut Creek, CA 94596.
- ⁸ Flexstar®, fomesafen, Syngenta Crop Protection, Inc., P.O. Box 18300, Greensboro, NC 27419.
- ⁹ Fusion®, fluazifop-P-butyl + fenoxaprop-P-ethyl, Syngenta Crop Protection, Inc., P.O. Box 18300, Greensboro, NC 27419.
- ¹⁰ Roundup WeatherMax®, glyphosate, Monsanto Company, 800 North Lindbergh Blvd., St. Louis, MO 63167.
- ¹¹ Select®, clethodim, Valent U.S.A. Corporation Agricultural Products, P.O. Box 8025, Walnut Creek, CA 94596.
- ¹² Sencor®, metribuzin, Bayer CropScience, 2 T.W. Alexander Drive, P.O. Box 12014, Research Triangle Park, NC 27709.
- ¹³ Dual Magnum®, s-metolachlor, Syngenta Crop Protection, Inc., P.O. Box 18300, Greensboro, NC 27419.
- ¹⁴ Parallel™ PCS, metolachlor, Makhteshim Agan of North America, Inc., 4515 Falls of Neuse Road, Suite 300, Raleigh, NC 27609.
- ¹⁵ Stalwart®, metolachlor, Sipcam Agro USA, Inc., 300 Colonial Center Parkway, Suite 230, Roswell, GA 30076.

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