Original Research Article

Cotton Weed Management Systems in Conventional and Conservation Tillage

ABSTRACT

Weed management trials were established near Lubbock, TX in 2017 and 2018 to compare systems in both conventional and conservation tillage. Four herbicide systems were included for both the conventional and conservation tillage. Conventional tillage treatments included trifluralin preplant incorporated (PPI) fb no preemergence (PRE) fb dicamba + glyphosate + acetochlor early postemergence (EPOST) fb dicamba + glyphosate midpostemergence (MPOST), trifluralin PPI fb prometryn PRE fb dicamba + glyphosate EPOST fb dicamba + glyphosate + acetochlor MPOST, no PPI fb prometryn PRE fb dicamba + glyphosate EPOST fb dicamba + glyphosate + acetochlor MPOST, trifluralin PPI fb prometryn PRE fb glyphosate EPOST fb glyphosate + acetochlor MPOST. Conservation tillage treatments included dicamba + glyphosate early preplant (EPP) fb paraquat + prometryn PRE fb dicamba + glyphosate EPOST fb dicamba + glyphosate MPOST, dicamba + glyphosate + flumioxazin EPP fb paraquat + prometryn PRE fb dicamba + glyphosate EPOST fb dicamba + glyphosate MPOST, glyphosate EPP fb dicamba + prometryn fb dicamba + glyphosate EPOST fb dicamba + glyphosate MPOST, no EPP fb dicamba + prometryn fb dicamba + glyphosate EPOST fb dicamba + glyphosate MPOST. Visual weed control for Russian thistle, kochia, and Palmer amaranth was recorded at cotton planting and 14 days after planting. Palmer amaranth control was recorded at 14 and 28 days after the EPOST and MPOST treatments. Effective season-long control of Palmer amaranth (>98%) was achieved using various dicamba-based herbicide systems in both conventional and conservation tillage. Glyphosate-based herbicide systems controlled Palmer amaranth <53% in 2017 and <84% in 2018 due to the number of glyphosate-resistant weeds present. All dicamba treatments controlled Palmer amaranth >83% in 2017 and >98% in 2018.

Keywords: weed management, cotton, dicamba-tolerant, glyphosate, glufosinate, Palmer amaranth

1. INTRODUCTION

Effective weed control is an essential aspect of upland cotton [*Gossypium hirsutum* (L.)] production systems. Weed control has evolved in cotton systems over time, especially with the introduction of glyphosate-tolerant cotton. Prior to glyphosate-tolerant cotton, Palmer amaranth [*Amaranthus palmeri* (S. Wats)] was controlled using a combination of tillage and soil residual herbicides applied either preplant incorporated (PPI), preemergence (PRE), postemergence (POST), or postemergence-directed using a hooded sprayer [1,2].

Glyphosate-tolerant cotton allowed growers broad-spectrum weed control and flexibility of application timing [3]. This differed from previous years in which soil residual herbicides were the foundation of weed management systems. Glyphosate became a widely used postemergence herbicide which provided excellent Palmer amaranth control. However, its efficacy caused an overreliance on a single mode of action and increased selection pressure for resistant weeds. Glyphosate-resistant Palmer amaranth was first discovered in Georgia in 2004 and was first confirmed on the Texas High Plains (THP) in 2011 [4]. This resulted in a shift back to a more balanced approach of multiple modes of action and residual herbicides as well as tillage. In 2016, auxin-tolerant cotton cultivars were first introduced with the ability to spray dicamba or 2,4-D over-the-top of cotton. This added an effective postemergence weed control option for producers struggling to control glyphosate-resistant (GR) Palmer amaranth.

The THP is a region prone to soil erosion, to reduce this, producers are adopting conservation management practices, such as strip-tillage, reduced tillage, or no-tillage with cover crops. Glyphosate tolerance allowed producers to reduce tillage when controlling weeds [5]; however tillage has been an effective tool for the control of weeds over time and has been one of the only options to control GR Palmer amaranth postemergence in cotton in the THP. Therefore, the objectives of the study were to evaluate dicamba-based herbicide programs in conservation and conventional tillage systems for control of glyphosate-resistant Palmer amaranth.

2. MATERIALS AND METHODS

Site description and experimental design

Field trials were conducted in 2017 and 2018 at the Texas A&M AgriLife Research and Extension Center near Lubbock, TX, USA (33.68816, -101.83171) to evaluate weed management systems in upland cotton in both conservation and conventional tillage systems and their control on Palmer amaranth, kochia [*Kochia scoparia* (L. Schrad.)], and Russian thistle [*Salsola tragus* (L.)]. The trial location changed each year to follow corn [*Zea mays* (L.)]. The trial was arranged in a randomized complete block design with four replications. Plots were four rows by 9.1 m in length with a two-row running check. The soil texture is an Acuff loam (Fine-loamy, mixed thermic Aridic Paleustolls) with less than 1% organic matter and a pH of 7.9. For these experiments, Deltapine DP 1612 B2XF in 2017 and Deltapine DP 1822 XF in 2018 were planted on 102 cm row spacing at a depth of 3.8 cm and a seeding rate of 128,440 seeds ha^{-1}. Cotton was planted on 15 May 2017 and 21 May 2018. Rainfall totaled 374 mm in 2017 and 304 mm in 2018. Plots received supplemental furrow irrigation totaling 152 mm in 2017 and 229 mm in 2018.

The trials followed corn in both years with the conventional and conservation tillage systems treated differently. For both tillage systems, corn stalks were shredded after harvest, and beds relisted. For the conservation tillage system, this was the only tillage used, and the subsequent cotton crop was planted directly into the stubble and relisted beds. The conventional tillage plots were disked in the early spring before the trifluralin PPI treatments were incorporated using a spring tooth harrow, and the beds were subsequently relisted. Immediately prior to planting, the beds were prepped using a rod weeder to clean up any weeds and prepare the beds for planting. However, no in-season tillage or cultivation was utilized.

Treatment application

Herbicide and application rates are listed in Table 1 and herbicide systems are summarized in Table 2. The PPI treatments were applied on 22 March 2017 and 9 April 2018, early preplant burndown (EPP) treatments were applied 4 April 2017 and 3 April 2018, preemergence (PRE) treatments were applied at planting. Postemergence applications were applied when Palmer amaranth was 5 to 10 cm tall, early postemergence (EPOST) treatments were applied on 9 June 2017 and 5 June 2018, and mid-postemergence (MPOST) treatments were applied on 10 July 2017 and 12 July 2018. The PPI treatments were applied using a compressed-air tractor mounted sprayer, and the EPP, PRE, and

POST treatments were applied with a CO2 pressurized backpack sprayer, both sprayer systems were calibrated to deliver 140 L ha^{-1} at 220 kPa and 4.8 km hr^{-1}. The sprayers were equipped with TurboTeeJet 11002 nozzles (Spraying Systems Co. North Avenue and Schmale Roade, Wheaton IL 60188) for non-dicamba applications and TurboTeeJet Induction 11002 nozzles for the dicamba applications.

Table 1. Herbicides and application rates for 2017 and 2018 systems trials near Lubbock, TX.

Herbicide common names	Brand names	Application rates kg ai or ae ha^{-1}
trifluralin	Treflan 4EC	1.12
prometryn	Caparol 4L	1.12
flumioxazin	Valor	0.07
paraquat	Gramoxone	0.56
glyphosate	Roundup PowerMax	1.27
dicamba	XtendiMax with Vaporgrip Technology	0.56
acetochlor	Warrant	1.27

Table 2. Weed management systems in 2017 and 2018.

Tillage System	PPI/EPP	PRE	EPOST	MPOST
Conventional	trifluralin	No PRE	dicamba + glyphosate +acetochlor	dicamba + glyphosate
	trifluralin	prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor
	No PPI	prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor
	trifluralin	prometryn	glyphosate	glyphosate + acetochlor
Conservation	dicamba + glyphosate	paraquat + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor
	dicamba + glyphosate + flumioxazin	paraquat + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor
	glyphosate	dicamba + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor
	No EPP	dicamba + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor

Abbreviations: PPI, preplant incorporated; EPP, early preplant; PRE, preemergence; EPOST, early postemergence; MPOST, mid postemergence

Measurements

Visual control was recorded at planting, 14 days after planting (DAP), and 14 and 28 DAT for both POST applications. Visual control estimates were on a scale of 0 to 100%, where 0 equals no weed control and 100 equals complete control and were compared to the two-row running check [6]. Cotton was harvested on 17 October 2017 and 1 October 2018 using a John Deere small plot stripper with yield estimated using a lint turnout of 33%.

Statistical analysis

Visual control and cotton lint yield were analyzed using PROC GLIMMIX at a significance level of α = 0.05 using SAS 9.4. Year was significant, so 2017 and 2018 data were analyzed separately. Visual control was compared within weed species and each rating date. Differences were determined using Fisher's Protected LSD at α = 0.05. Treatment was the fixed effect and replication was the random effect.

3. RESULTS AND DISCUSSION

Russian thistle, kochia, and Palmer amaranth control at cotton planting

Visual control ratings of Russian thistle, kochia, and Palmer amaranth for PPI and EPP treatments were evaluated at cotton planting for 2017 and 2018. In 2017 in the conventional tillage, trifluralin applied PPI in the conventional tillage system controlled Russian thistle, kochia, and Palmer amaranth greater than 96, 99, and 89%, respectively (Table 3). Glyphosate EPP in the conservation tillage system controlled Russian thistle and kochia 91 and 94% but did not control Palmer amaranth (0%). Dicamba + glyphosate EPP increased control of Russian thistle, kochia and Palmer amaranth to 95, 100, and 70%, respectively. Including flumioxazin increased Palmer amaranth control to 89%, Russian thistle and kochia were controlled at 95 and 99%, respectively.

Insufficient emergence of Russian thistle and kochia occurred in 2018 to effectively evaluate weed control. At planting, Palmer amaranth control was >85% with trifluralin PPI. Glyphosate alone controlled Palmer amaranth 43%. While dicamba + glyphosate controlled Palmer amaranth 80%, control improved to 96% with flumioxazin in the tank-mix.

Table 3. Palmer amaranth, Russian thistle, and kochia control at planting in 2017 and 2018.

Weed control system		**2017**			**2018**
Tillage System	**PPI/EPP**	**Russian thistle**	**kochia**	**Palmer amaranth**	**Palmer amaranth**
		------------------- % control ------------------			
Conventional	trifluralin	98 a	100 a	89 a	85 bc
	trifluralin	96 ab	99 a	89 a	89 b
	No PPI	0 c	0 c	0 c	0 e
	trifluralin	98 a	99 a	90 a	85 bc
Conservation	dicamba + glyphosate	99 a	100 a	70 b	80 c
	dicamba + glyphosate + flumioxazin	95 ab	99 a	89 a	96 a
	glyphosate	91 b	94 b	0 c	43 d
	No EPP	0 c	0 c	0 c	0 e

Abbreviations: PPI, preplant incorporated; EPP, early preplant; PRE, preemergence; EPOST, early postemergence; MPOST, mid postemergence

Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD test at P < 0.05. Columns with no letter are not significantly different.

Russian thistle, kochia, and Palmer amaranth control 14 DAP

Visual control of Russian thistle, kochia, and Palmer amaranth with PRE treatments was evaluated 14 DAP for 2017 and 2018. Conventional tillage plots were rod-weeded at planting which removed any emerged weeds prior to application of PRE herbicides. In 2017, trifluralin PPI with no PRE controlled Russian thistle, kochia, and Palmer amaranth 99, 100, and 94%, respectively (Table 4). No PPI fb prometryn PRE controlled Russian thistle, kochia, and Palmer amaranth 95, 94, and 79%, respectively. Trifluralin PPI fb prometryn PRE controlled Russian thistle and kochia 100% while controlling Palmer amaranth greater than 94%. Conservation tillage plots had most effective control when using paraquat and prometryn PRE. The dicamba + glyphosate with or without flumioxazin EPP fb paraquat and prometryn PRE controlled all three weeds greater than 99%. Glyphosate fb dicamba + prometryn PRE controlled Russian thistle and kochia greater than 97%, but Palmer amaranth control decreased to 83%. Less effective Russian thistle, kochia, and Palmer amaranth control (76, 79, and 81%) was achieved with dicamba + prometryn PRE that did not receive an EPP treatment.

In 2018, when either trifluralin PPI or prometryn PRE was applied alone, control of Palmer amaranth was 89 to 90%, but when trifluralin PPI fb prometryn PRE was applied, control of Palmer amaranth increased to 98 to 99%. All combinations of EPP treatments controlled Palmer amaranth greater than 92%, with the treatments including dicamba + glyphosate with or without flumioxazin EPP fb paraquat + prometryn PRE increasing control to greater than 97%. These results indicate the value of an EPP treatment in conservation tillage systems when a preplant incorporated herbicide cannot be used.

Table 4. Palmer amaranth, Russian thistle, and kochia control 15 days after preemergence in 2017 and 2018.

Weed control system			2017			2018
Tillage System	**PPI/EPP**	**PRE**	**Russia n thistle**	**kochia**	**Palmer amaranth**	**Palmer amaranth**
			----------------------	% control	----------------------	
Conventional	trifluralin	No PRE	99 a	100 a	94 a	90 c
	trifluralin	prometryn	100 a	100 a	95 a	98 a
	No PPI	prometryn	95 b	94 b	79 b	89 c
	trifluralin	prometryn	100 a	100 a	94 a	99 a
Conservation	dicamba + glyphosate	paraquat + prometryn	100 a	100 a	99 a	97 a
	dicamba + glyphosate + flumioxazin	paraquat + prometryn	100 a	100 a	100 a	99 a
	glyphosate	dicamba + prometryn	98 ab	97 a	83 b	96 ab
	No EPP	dicamba + prometryn	76 c	79 c	81 b	92 bc

Abbreviations: PPI, preplant incorporated; EPP, early preplant; PRE, preemergence
Means within a column followed by the same letter are not significantly different according to Fisher’s Protected LSD test at $\alpha < 0.05$. Columns with no letter are not significantly different.

Palmer amaranth control 14 and 28 days after EPOST

Visual control of Palmer amaranth was evaluated 14 and 28 days after EPOST application. In 2017, Palmer amaranth control ranged from 75 to 96% in the conventional and 85 to 97% in the conservation tillage 14 DAT (Table 5). In the conventional tillage, trifluralin PPI fb prometryn PRE fb glyphosate alone controlled Palmer amaranth 79%, while including dicamba with or without acetochlor improved control to 90 to 96%. In the conservation tillage systems, all EPOST treatments included dicamba + glyphosate alone and controlled Palmer amaranth 85 to 97%. At 28 DAT, the trifluralin PPI fb prometryn PRE fb glyphosate controlled Palmer amaranth 70%, while all other treatments in both tillage systems controlled Palmer amaranth 81 to 94%.

In 2018, Palmer amaranth control was 63 to 74% when no PPI or EPP was applied, while all other treatments controlled Palmer amaranth 81 to 97% 14 DAT. At 28 DAT, all treatments controlled Palmer amaranth 85 to 95%.

Table 5. Palmer amaranth control 14 and 28 days after early postemergence in 2017 and 2018.

Weed control system				2017		2018	
Tillage System	PPI/EPP	PRE	EPOST	14 DAT	28 DAT	14 DAT	28 DAT
				---------- % control ----------			
Conventional	trifluralin	No PRE	dicamba + glyphosate + acetochlor	95 ab	93 ab	92 ab	93 ab
	trifluralin	prometryn	dicamba + glyphosate	96 a	94 ab	93 ab	95 a
	No PPI	prometryn	dicamba + glyphosate	90 ab	94 ab	63 e	91 ab
	trifluralin	prometryn	glyphosate	79 c	70 c	81 cd	85 b
Conservation	dicamba + glyphosate	paraquat + prometryn	dicamba + glyphosate	85 bc	81 bc	91 ab	90 ab
	dicamba + glyphosate + flumioxazin	paraquat + prometryn	dicamba + glyphosate	97 a	94 a	97 a	85 b
	glyphosate	dicamba + prometryn	dicamba + glyphosate	93 ab	93 ab	86 bc	89 ab
	No EPP	dicamba + prometryn	dicamba + glyphosate	85 bc	87 ab	74 d	90 ab

Abbreviations: PPI, preplant incorporated; EPP, early preplant; PRE, preemergence; EPOST, early postemergence.

Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD test at $\alpha < 0.05$. Columns with no letter are not significantly different.

Palmer amaranth control 14 and 28 days after MPOST

Palmer amaranth control was evaluated 14 and 28 days after MPOST application. In 2017, Palmer amaranth control ranged from 91 to 100% in all treatments except trifluralin PPI fb prometryn PRE fb glyphosate EPOST fb glyphosate + acetochlor, which controlled this weed 59% 14 DAT (Table 6). Palmer amaranth was controlled 83 to 100% 28 DAT, while the trifluralin PPI fb prometryn PRE fb glyphosate EPOST fb glyphosate + acetochlor treatment controlled this weed 53%. In 2018, Palmer amaranth control ranged from 98 to 100% for all treatments at both 14 and 28 DAT except trifluralin PPI fb prometryn PRE fb glyphosate EPOST fb glyphosate + acetochlor which was 84% at both 14 and 28 DAT.

The most effective season-long control was achieved with treatments including dicamba regardless of residual herbicides applied PPI, EPP, PRE, or tank mixed POST when compared to treatments with glyphosate applied POST alone, due to the large number of glyphosate-resistant Palmer amaranth. Similar results were observed by Inman et al. where Palmer amaranth density was reduced when dicamba + glyphosate was used in a tank-mix, regardless of residual herbicides used PRE or applied POST in the tank-mix [7]. Dodds et al. had similar findings where GR Palmer amaranth was effectively controlled using dicamba POST, and in studies in North Carolina, Palmer amaranth control was greater using dicamba systems when compared to glyphosate systems, regardless of timing [8,9].

Table 6. Palmer amaranth control 14 and 28 days after midpostemergence in 2017.

	Weed control system				2017	
Tillage System	**PPI/EPP**	**PRE**	**EPOST**	**MPOST**	**14 DAT**	**28 DAT**
					---- % control ---	
Conventional	trifluralin	No PRE	dicamba + glyphosate +acetochlor	dicamba + glyphosate	100 a	100 a
	trifluralin	prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	96 a	96 ab
	No PPI	prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	96 a	91 ab
	trifluralin	prometryn	glyphosate	glyphosate + acetochlor	59 b	53 c
Conservation	dicamba + glyphosate	paraquat + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	91 a	91 ab
	dicamba + glyphosate+ flumioxazin	paraquat + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	98 a	98 ab
	glyphosate	dicamba + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	95 a	90 ab
	No EPP	dicamba + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	91 a	83 b

Abbreviations: PPI, preplant incorporated; EPP, early preplant; PRE, preemergence; EPOST, early postemergence; MPOST, mid postemergence.

Means within a column followed by the same letter are not significantly different according to

Fisher's Protected LSD test at α < 0.05. Columns with no letter are not significantly different.

Table 7. Palmer amaranth control 14 and 28 days after midpostemergence in 2018.

Weed control system					2018	
Tillage System	**PPI/EPP**	**PRE**	**EPOST**	**MPOST**	**14 DAT**	**28 DAT**
					---- % control ---	
Conventional	trifluralin	No PRE	dicamba + glyphosate +acetochlor	dicamba + glyphosate	100 a	100 a
	trifluralin	prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	100 a	100 a
	No PPI	prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	100 a	100 a
	trifluralin	prometryn	glyphosate	glyphosate + acetochlor	84 b	84 b
Conservation	dicamba + glyphosate	paraquat + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	100 a	100 a
	dicamba + glyphosate + flumioxazin	paraquat + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	98 a	98 a
	glyphosate	dicamba + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	99 a	99 a
	No EPP	dicamba + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	99 a	99 a

Abbreviations: PPI, preplant incorporated; EPP, early preplant; PRE, preemergence; EPOST, early postemergence; MPOST, mid postemergence.
Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD test at α < 0.05. Columns with no letter are not significantly different

Cotton lint yield

In 2017, cotton lint yield ranged from 898 to 1124 kg ha^{-1} in the conventional tillage and 853 to 1339 kg ha^{-1} in the conservation tillage (Table 7). Similar yields were produced with all herbicide systems in the conventional tillage. However, in conservation tillage, yields were lower in treatments that did not receive a dicamba + glyphosate EPP application. This was likely due to less effective early-season control of the three weed species.
In 2018, lint yields ranged from 588 to 845 kg ha^{-1} in conventional tillage and 547 to 532 kg ha^{-1} in conservation tillage. In the conventional tillage, similar yields were produced in herbicide systems that included trifluralin compared to the no PPI treatment. In the treatment that included trifluralin PPI fb prometryn PRE, yields were not reduced. In the conservation tillage, similar yields were produced with all treatment systems except for the one with no EPP applied. This was similar to yield results in 2017.

Table 8. Cotton lint yield in 2017 and 2018.

Weed control system					2017	2018
Tillage System	**PPI/EPP**	**PRE**	**EPOST**	**MPOST**	**Yield**	**Yield**
					----kg ha^{-1}----	
Conventional	trifluralin	No PRE	dicamba + glyphosate +acetochlor	dicamba + glyphosate	985 bc	861 a
	trifluralin	prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	1124 abc	824 a
	No PPI	prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	948 bc	588 b
	trifluralin	prometryn	glyphosate	glyphosate + acetochlor	898 c	845 a
Conservation	dicamba + glyphosate	paraquat + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	1215 ab	832 a
	dicamba + glyphosate + flumioxazin	paraquat + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	1339 a	685 ab
	glyphosate	dicamba + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	898 c	710 ab
	No EPP	dicamba + prometryn	dicamba + glyphosate	dicamba + glyphosate +acetochlor	853 c	547 b

Abbreviations: PPI, preplant incorporated; EPP, early preplant; PRE, preemergence; EPOST, early postemergence; MPOST, mid postemergence.
Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD test at $\alpha < 0.05$. Columns with no letter are not significantly different.

These results are similar to studies comparing conventional and conservation tillage systems in both glyphosate and glufosinate systems, where in year one, conventional tillage had higher yields than the conservation tillage, with no differences in year two, and the conservation tillage out yielded the conventional tillage in year three [10]. Effective herbicide treatments in either tillage system can produce similar yields when using a dicamba-based system in areas with GR Palmer amaranth.

4. CONCLUSION

The introduction of auxin-tolerant cotton varieties allows growers more modes of action to effectively control GR Palmer amaranth. Effective season-long control of Palmer amaranth (>98%) was achieved in both conventional and conservation tillage systems using dicamba-based herbicide programs. Glyphosate systems, even when partnered with residual herbicides and tillage prior to planting, did not effectively control Palmer amaranth due to high densities of glyphosate-resistance. Early-season control is key to producing greater lint yields. Cotton that is competing with early emerging weeds like kochia or Russian thistle can affect early-season growth and reduce yield potential. In conservation tillage, dicamba and glyphosate controlled emerged weeds, while the addition of flumioxazin maintains effective weed control up to planting. Trifluralin applied PPI reduced emergence of early weeds and added residual control up to planting in conventional tillage systems. The dicamba-based herbicide programs that utilize residual herbicides throughout the growing season can be incorporated in minimal and no-tillage systems to control troublesome weeds, including GR Palmer amaranth throughout the season.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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