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WEED SCIENCE

Assessing the Potential for Fluridone to Reduce the Number of Postemergence Herbicide Applications in Glyphosate-Resistant Cotton

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ABSTRACT

With the evolution of glyphosate-resistant weeds, cotton producers now rely on multiple applications of soil-residual herbicides tank-mixed with postemergence (POST) herbicides. However, the current soil-residual herbicides represent a relatively low number of herbicide mechanisms of action (MOAs), with the same few MOAs being utilized year after year. Therefore, it is important to introduce new MOAs to slow the likelihood of further resistance development. A field experiment was conducted in 2012 and 2013 to determine if fluridone, a bleaching herbicide currently not used in any agronomic cropping system, applied preemergence (PRE) would provide effective season-long control of Palmer amaranth as well as reduce the number of POST applications throughout the season. Fluridone PRE at 224, 336, and 448 g ai ha^{-1} did not eliminate the need for POST herbicides for Palmer amaranth control in cotton in either year. Fluridone, regardless of rate, provided comparable control to fluometuron in 2012; however in 2013, fluometuron provided less control than fluridone. Although moderate season-long control was observed in 2013, greater seed cotton yields were obtained in 2013 than in 2012, which is likely a result of greater control during the critical period for weed control. Based on this experiment, fluridone will not provide effective season-long Palmer amaranth control in the absence of a multiple POST-herbicide program.

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Prior to the commercialization of glyphosate-resistant (GR) crops in 1997, weed management in cotton (*Gossypium hirsutum* L.) relied upon combining several factors: 1) multiple soil-residual herbicide applications, 2) multiple POST-herbicide applications, and 3) tillage (Burke et al., 2005; Young, 2006). Since then, the adoption of this technology has increased from 37% utilization in 2000 to almost 100% utilization by 2011 (Norsworthy et al., 2011; USDA NASS, 2000, 2011). For several years following GR cotton commercialization, producers were limited to applying glyphosate before the four-leaf cotton growth stage; however, enhanced GR cotton was commercialized allowing multiple applications of glyphosate throughout the growing season in 2006 (Huff et al., 2010). Additional benefits of utilizing GR technology included less reliance on tillage, reduced herbicide costs, and minimal crop injury (Young, 2006). However, the benefits of a GR crop lead to producers relying on glyphosate as a sole means of weed control. With time, the evolution of GR weeds was inevitable (Culpepper et al., 2006). Currently, 14 weeds have been confirmed resistant to glyphosate in the U.S. (Heap, 2015), seven of which can be found in Arkansas (Heap, 2015).

Palmer amaranth (*Amaranthus palmeri* S. Wats.) has become the most troublesome GR weed across the southern U.S., due in part, to its extended emergence period (Jha and Norsworthy, 2009; Jha et al., 2006) and prolific growth capabilities (Norsworthy et al., 2008; Sellers et al., 2003). This prolific growth rate allows Palmer amaranth to reach heights greater than 2 m (Horak and Loughin, 2000), which exceeds the heights of soybean [*Glycine max* (L.) Merr.] and cotton. As a dioecious plant, female plants are easily distinguishable from male plants with a thick, spiked inflorescence up to 0.5 m in length and sharp bracts throughout the inflorescence (Horak and Peterson, 1995). Furthermore, to ensure greater offspring emergence a single female Palmer amaranth plant can produce up to 600,000 seeds (Keeley et al., 1987). The high dispersal of both pollen (Sonoskie et al., 2009) and seed (Norsworthy et al., 2009, 2014) by

Palmer amaranth allows for the GR trait to rapidly spread across a field and larger geographies. As a result of these characteristics, Palmer amaranth can be extremely competitive with agronomic crops such as cotton, with cotton lint yield reductions up to 92% at 0.9 plants m^{-2} (Rowland et al., 1999).

The standard cotton weed management program for GR cotton in Arkansas consists of seven to nine herbicides applied periodically throughout the season. These include burndown, preemergence, postemergence, post-directed, and layby applications. Previous research has reported that the exclusion of soil-residual herbicides at the layby application could allow late-season weed interference, for which the likelihood of cotton lint yield reduction is highly probable (Tingle and Chandler, 2004).

Most of the herbicides that make up the standard cotton weed management program in Arkansas are soil-residual herbicides belonging to multiple herbicide method of action (MOA)s. Weed Science Society of America (WSSA) Group 7 (fluometuron and diuron), Group 14 (fomesafen and flumioxazin), and Group 15 (metolachlor and acetochlor) herbicides are heavily relied upon for residual weed control in cotton. With the high propensity for Palmer amaranth to evolve resistance to herbicides, it would be beneficial to use another effective MOA for its control in cotton, especially because the aforementioned herbicides also are used commonly in soybean.

Developed as EL-171 in the early 1970s, fluridone is a pigment inhibitor classified as a WSSA Group 12 herbicide (Waldrep and Taylor, 1976) that has been used extensively to control submersed and floating weeds in aquatic environments (Richardson, 2008). Though fluridone was extensively tested in cotton, registration for use was not pursued. However, fluridone PRE at 0.3 to 2.4 kg ai ha^{-1} did not injure cotton and controlled annual grass and broadleaf weeds such as barnyardgrass (*Echinocloa crus-galli* L. Beauv), johnsongrass (*Sorghum halepense* L.), tall morningglory (*Ipomoea purpurea* L. Roth), and redroot pigweed (*Amaranthus retroflexus* L.) (Waldrep and Taylor, 1976).

Considering fluridone is a Group 12 herbicide that currently is not used in cotton, has lengthy soil persistence (Banks et al. 1979; Shea and Weber, 1983), and activity on many grass and broadleaf weeds, it is important to determine if this herbicide can be incorporated into a cotton weed management program. Therefore, the objective of this experiment was to evaluate the efficacy of PRE-applied fluridone compared to fluometuron. Additionally, fluridone and fluometuron were used to determine the number of POST-herbicide applications needed for effective weed control in GR cotton.

MATERIALS AND METHODS

Field experiments were conducted in 2012 and 2013 at the Lon Mann Cotton Research Center in Marianna, AR, on a Zachary silt loam soil (fine-silty, mixed, active, thermic Typic Albaqualfs) with 8% sand, 80% silt, 12% clay, 1.8% organic matter, and a pH of 6.9. The experimental design was a randomized complete block design in a two-factor factorial arrangement of treatments replicated four times. The two factors were four PRE-herbicide treatments and five POST treatments.

PRE-herbicide treatments included fluometuron at 1,120 g ai ha^{-1} and fluridone at 224, 336, and 448 g ha^{-1} applied immediately after planting. The POST-herbicide treatments included: 1) no POST herbicide (hereafter referred to as NO POST), 2) monosodium acid methanarsonate (MSMA) at 2,240 g ai ha^{-1} plus flumioxazin at 72 g ai ha^{-1} applied post-directed/layby (PDIR/LAYBY) (hereafter referred to as 1-POST), 3) glyphosate at 840 g ae ha^{-1}plus prometryn at 1,120 g ai ha^{-1} applied to 8- to 10-leaf cotton followed by MSMA plus flumioxazin (PDIR/LAYBY) (hereafter referred to as 2-POST), 4) glyphosate plus *S*-metolachlor at 1,070 g ai ha^{-1} applied to 4- to 5-leaf cotton followed by glyphosate plus prometryn to 8- to 10-leaf cotton followed by MSMA plus flumioxazin (PDIR/LAYBY) (hereafter referred to as 3-POST), and 5) glyphosate plus *S*-metolachlor (2-leaf) followed by glyphosate plus *S*-metolachlor (4- to 5-leaf) followed by glyphosate plus prometryn (8- to 10-leaf) followed by MSMA plus flumioxazin (PDIR/LAYBY) (hereafter referred to as 4-POST). A nontreated control was included for comparison. Plot size was 7.6 m long with four 0.96-m rows in both years. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 140 L ha^{-1} at 276 kPa using TeeJet 110015 flat-fan nozzles (TeeJet Technologies, Springfield, IL). The PDIR/LAYBY treatments were applied using the same CO_2-pressurized backpack sprayer setup equipped with TeeJet 110015 flat-fan drop nozzles. Formulations and manufacturers of all herbicide products evaluated in this experiment can be found in Table 1.

Table 1. Herbicide products used, production company, and application rate of treatments applied at the Lon Mann Cotton Research Center near Marianna, AR in 2012 and 2013

Herbicide	Trade Name	Company	Rate(s) [z,y]
			g ai or ae ha^{-1}
Fluometuron	Cotoran 4L	MANA, Inc.	1,120
Fluridone	Brake 2L	SePRO Corporation	224, 336, 448
Glyphosate	Roundup PowerMax	Monsanto	840
S-metolachlor	Dual Magnum	Syngenta	1,070
Prometryn	Caparol 4L	Syngenta	1,120
MSMA	MSMA 6 Plus	Drexel Chemical Co.	2,240
Flumioxazin	Valor SX	Valent	72

[z] Fluridone rates: 224, 336, and 448 g ai ha^{-1}.

[y] Glyphosate rate is acid equivalent.

Phytogen 375 (Widestrike®, Genuity®, Roundup Ready Flex®) was seeded at 11 seeds m^{-1} row on 9 May 2012 and 16 May 2013. Cotton was seeded 2.5-cm deep in both years. All studies were conducted using no-till methods with standard cotton production practices.

Control of barnyardgrass, broadleaf signalgrass [*Urochloa platyphylla* (Nash) R.D. Webster], Palmer amaranth, and pitted morningglory (*Ipomoea lacunosa* L.) was evaluated. In both years, the test site contained a natural population of mixed GR and GR-susceptible Palmer amaranth. For the four evaluated weeds, plant populations and heights were recorded in the nontreated plot immediately following each POST application. In both years, Palmer amaranth populations averaged between 40 to 50 plants m^{-2}; with heights ranging between 8 to 25 cm at the second POST timing, 38 to 45 cm at the third POST timing, and 50 to 60 cm at the fourth POST timing. Pitted morningglory populations averaged between 24 to 28 plants m^{-2}; with height ranging between 8 to 20 cm at the second POST timing, 76 to 81 cm at the third POST timing, and 91 to 121 cm at the fourth POST timing. Barnyardgrass populations averaged between 20 to 35 plants m^{-2}; with heights ranging between 15 to 25 cm at the second POST timing, 30 to 38 cm at the third POST timing, and 45 to 60 cm at the fourth POST timing. Broadleaf signalgrass populations averaged between 8 to 30 plants m^{-2}; with heights ranging between 15 to 20 cm at the second POST timing, 25 to 30 cm at the third POST timing, and 38 to 45 cm at the fourth POST timing.

Plots were visually evaluated every 7 to 14 days after treatment (DAT) for weed control and cotton injury on a scale of 0 to 100%, with 0 being no control or injury and 100% being plant or crop death; however, only the 3 and 12 weeks after planting (WAP) evaluations are presented. Seed cotton yield was determined by harvesting the center two rows of plots using conventional harvesting equipment on 2 November 2012 and on 25 October 2013.

All data were analyzed by ANOVA using JMP Pro Version 10.0 (SAS Institute Inc., Cary, NC), and means were separated with Fisher's LSD ($\alpha = 0.05$). Due to observed interactions with year, treatments were analyzed separately for 2012 and 2013. Seven preplanned contrasts were constructed to compare: 1) fluridone PRE at 224 g ha^{-1} vs. fluometuron, 2) fluridone PRE at 336 g ha^{-1} vs. fluometuron, 3) fluridone PRE at 448 g ha^{-1} vs. fluometuron, 4) 4-POST program vs. 3-POST program, 5) 4-POST program vs. 2-POST program, 6) 4-POST program vs. 1-POST program, 7) 4-POST program vs. NO-POST program, with differences reported at a $p \leq 0.05$.

RESULTS AND DISCUSSION

Environmental Data and Cotton Growth. In 2012, PRE-herbicide treatments received insufficient precipitation for proper activation, which decreased weed control. In an attempt to overcome the lack of precipitation, furrow-irrigation was utilized with 1 wk after the first POST application. However, early season cotton growth was slowed as a result of the limited precipitation, particularly in herbicide programs lacking an early POST application.

In 2013, timely precipitation was received throughout the growing season, with approximately 5 cm of rainfall received within days of the PRE-herbicide applications. Furthermore, cotton growth benefited from the frequent precipitation and irrigation events received throughout the 2013 growing season. Regardless of precipitation amounts during the season, no cotton injury was observed either year (data not shown).

Palmer Amaranth and Pitted Morningglory Control. No PRE treatment provided greater than 80% control of Palmer amaranth at 3 WAP in 2012 (Table 2), which was due to the lack of activating precipitation. Regardless of the POST application timings, little to no differences were observed between fluometuron and fluridone at all rates PRE. Averaged over PRE herbicides, the 4-POST program provided 75 to 85% control of Palmer amaranth, which was greater than POST programs containing two or fewer timings (11-65%). However, Palmer amaranth control 12 WAP following the 3-POST program was comparable to the 4-POST program. Scott et al. (2002) emphasized the need for an effective POST herbicide to be tank-mixed with soil-residual herbicides in cotton to provide extended control of Palmer amaranth, most importantly in instances where soil-residual herbicides are not activated.

Table 2. Palmer amaranth and pitted morningglory control as influenced by preemergence herbicide and postemergence application timing at the Lon Mann Cotton Research Center near Marianna, AR in 2012 and 2013[z,y]

Treatment	Rate	POST application[x]	Control							
			2012				2013			
			Palmer amaranth		Pitted morningglory		Palmer amaranth		Pitted morningglory	
			3 WAP	12 WAP	3 WAP	12 WAP	3 WAP	12 WAP	3 WAP	12 WAP
	g ai ha^{-1}		%							
Fluometuron	1,120	NO POST	68 b	25 c	63 c	20 e	84 b	48 c	94 a	54 c
Fluridone	224	NO POST	76 a	18 cd	70 b	20 e	94 a	80 ab	95 a	64 b
Fluridone	336	NO POST	73 b	21 c	79 a	43 d	96 a	79 ab	100 a	86 b
Fluridone	448	NO POST	70 b	11 d	76 b	43 d	94 a	73 b	98 a	68 b
Fluometuron	1,120	1-POST	65 b	35 c	71 b	46 c	93 a	71 b	95 a	84 a
Fluridone	224	1-POST	75 a	15 d	69 b	44 cd	90 a	65 b	93 a	71 b
Fluridone	336	1-POST	66 b	16 d	76 b	50 c	91 a	81 ab	91 a	68 b
Fluridone	448	1-POST	71 b	21 c	73 b	51 c	90 a	64 bc	94 a	65 b
Fluometuron	1,120	2-POST	69 b	35 c	74 b	85 b	90 a	66 b	99 a	86 a
Fluridone	224	2-POST	78 a	63 b	86 a	100 a	91 a	71 b	89 a	83 a
Fluridone	336	2-POST	81 a	65 b	84 a	100 a	96 a	78 ab	91 a	83 a
Fluridone	448	2-POST	76 a	56 b	88 a	100 a	96 a	80 ab	96 a	100 a
Fluometuron	1,120	3-POST	75 a	79 a	84 a	100 a	89 a	78 ab	90 a	95 a
Fluridone	224	3-POST	60 b	74 a	68 b	100 a	93 a	83 a	85 b	100 a
Fluridone	336	3-POST	73 b	81 a	79 a	100 a	89 a	85 a	99 a	100 a
Fluridone	448	3-POST	45 c	60 b	70 b	100 a	94 a	84 a	93 a	86 a
Fluometuron	1,120	4-POST	85 a	84 a	81 a	100 a	95 a	89 a	98 a	100 a
Fluridone	224	4-POST	85 a	85 a	91 a	100 a	94 a	90 a	95 a	100 a
Fluridone	336	4-POST	89 a	78 a	89 a	100 a	96 a	89 a	99 a	99 a
Fluridone	448	4-POST	76 a	75 a	78 a	100 a	95 a	93 a	98 a	99 a
Contrast										
Fluridone 224 vs. Fluometuron				NS		NS		0.0363		NS
Fluridone 336 vs. Fluometuron				NS		0.0006		0.0002		NS
Fluridone 448 vs. Fluometuron				NS		0.0005		0.0090		NS
4-POST vs. 3-POST				NS		NS		0.0257		NS
4-POST vs. 2-POST				< 0.0001		NS		< 0.0001		0.0471
4-POST vs. 1-POST				< 0.0001		< 0.0001		< 0.0001		< 0.0001
4-POST vs. NO POST				< 0.0001		< 0.0001		< 0.0001		< 0.0001

[z] Means within a column followed by the same lowercase letter are not statistically different based on Fisher's LSD (0.05).

[y] Preemergence herbicides were applied the day of cotton planting.

[x] Timing of POST applications: (4-POST) glyphosate plus S-metolachlor (2-lf) followed by glyphosate plus S-metolachlor (4- to 5-lf) followed by glyphosate plus prometryn (8- to 10-lf directed) followed by MSMA plus flumioxazin (Layby directed); (3-POST) glyphosate plus S-metolachlor (4- to 5-lf) followed by glyphosate plus prometryn (8- to 10-lf directed) followed by MSMA plus flumioxazin (Layby directed); (2-POST) glyphosate plus prometryn (8- to 10-lf directed) followed by MSMA plus flumioxazin (Layby directed); (1-POST) MSMA plus flumioxazin (Layby directed). See text for rates of each POST herbicide.

Overall initial control of Palmer amaranth in 2013 was greater than 2012. This is likely a result of better activation of soil-residual herbicides within seven days of application. Three WAP, all PRE herbicide programs provided ≥ 89% control of Palmer amaranth control except for fluometuron alone with 84% control (Table 2). By 12 WAP, variable control of Palmer amaranth (48-93%) was observed across the herbicide programs. When no POST herbicide was applied, no differences were observed among fluridone rates for Palmer amaranth control 12 WAP (73-80%) and all rates of fluridone provided greater control than fluometuron PRE (48%). This difference in control is likely a result of the extended residual control of fluridone on *Amaranthus* weeds as noted previously (Waldrep and Taylor, 1976). However, no differences were observed between fluridone and fluometuron when followed by a POST herbicide application (Table 2). Contrasts revealed that a 4-POST program provided greater Palmer amaranth control than any other POST program.

Similar to Palmer amaranth control in 2012, pitted morningglory control was variable (63-91%) depending on the number of POST herbicides applied 3 WAP (Table 2). In the absence of a POST, fluridone PRE provided 70 to 79% pitted morningglory control, whereas fluometuron provided only 63% control 3 WAP. Greater activity of fluridone over fluometuron on pitted morningglory was evident based on contrasts. However, multiple POST applications were necessary to achieve effective control of pitted morningglory throughout the growing season.

In 2013, greater than 90% pitted morningglory control was observed at 3 WAP from most of the treatments (Table 2). These data suggests that when fully activated, soil-residual herbicides like fluridone and fluometuron can provide moderate to effective early season control of pitted morningglory. By 12 WAP, pitted morningglory control ranged from 86 to 100% when PRE herbicides were followed by 3- or 4-POST applications. Similarly, contrasts revealed that pitted morningglory control following the 4-POST program was superior to all programs that had two or fewer POST applications. Most of the POST applications contained glyphosate, and Scott et al. (2002) reported that the addition of glyphosate with soil-residual herbicides was beneficial for providing effective control of multiple *Ipomoea* spp. in cotton.

Barnyardgrass and Broadleaf Signalgrass Control. Barnyardgrass and broadleaf signalgrass control in this experiment were similar (Table 3). In both years, barnyardgrass and broadleaf signalgrass control were greater following the use of glyphosate in one or more of the POST applications. Similarly, previous research has shown that an application of *S*-metolachlor with glyphosate can provide excellent season-long control of barnyardgrass (Scroggs et al., 2007). In 2012, greater barnyardgrass at 12 WAP was obtained when fluridone was applied at either 336 or 448 g ha^{-1} than fluometuron PRE. Differences in barnyardgrass and broadleaf signalgrass control with fluridone and fluometuron were not observed 12 WAP in 2013.

Seed Cotton Yield. Due to poor activating rainfall in 2012, herbicide programs that did not contain multiple POST-herbicide applications had a significant decrease in cotton yield (Table 4). The shading of cotton by Palmer amaranth greatly contributed to the low cotton yields observed in 2012. In 2013, cotton yields were improved with no differences between the PRE treatments when followed by either 3-POST or 4-POST programs (Table 3).

Seed cotton yield following fluridone-based programs was similar to most fluometuron-containing programs over both years (Table 4). Furthermore, the value and need for multiple POST applications to protect against cotton yield reductions from weed interference was apparent in the drier year when the programs having 4-POST applications resulted in greater yield than those having 2-POST applications or fewer. In 2013, when the PRE-applied herbicides were activated, the need for POST herbicides to protect against cotton yield loss was less obvious, with only the 1-POST program having lower yields than the 4-POST program.

Fluridone and fluometuron require activation by rainfall or overhead-irrigation following application. Although not evaluated in these studies, it is important to note that the specific amount of rainfall or irrigation needed for optimum activation can differ between these two herbicides (unpublished data). Regardless of sufficient rainfall following application, fluridone-based herbicide programs provided equal to or superior weed control compared to fluometuron-based programs. Although fluridone has been reported to persist in the soil for a long period of time (Banks et al., 1979), as well as provide an extended level of control of redroot pigweed (Waldrep and Taylor, 1976), fluridone PRE alone will not provide season-long control of Palmer amaranth and supplemental POST applications will continue to be needed. In both years, Palmer amaranth was present at crop harvest, regardless of the intensity of the weed control program. Producers should be reminded frequently that escapes persisting through harvest will greatly contribute to the soil seedbank and further spread of herbicide resistance (Norsworthy et al., 2014); hence, alternative methods such as hand removal or other means of preventing seed additions to the seedbank might be needed.

Table 3. Barnyardgrass and broadleaf signalgrass control as influenced by preemergence herbicide and postemergence application timing at the Lon Mann Cotton Research Center near Marianna, AR in 2012 and 2013[z,y]

Treatment	Rate	POST application[x]	Control							
			2012				2013			
			Barnyardgrass		Broadleaf signalgrass		Barnyardgrass		Broadleaf signalgrass	
			3 WAP	12 WAP	3 WAP	12 WAP	3 WAP	12 WAP	3 WAP	12 WAP
	g ai ha^{-1}		%							
Fluometuron	1,120	NO POST	71 cd	28 f	73 c	29 d	93 a	65 d	100 a	76 b
Fluridone	224	NO POST	66 d	20 f	66 d	19 f	99 a	79 c	94 a	78 b
Fluridone	448	NO POST	80 bc	41 e	85 b	40 c	99 a	80 c	99 a	93 a
Fluridone	560	NO POST	83 b	55 d	83 b	40 c	100 a	80 c	96 a	78 b
Fluometuron	1,120	1-POST	79 c	79 c	78 b	24 e	100 a	89 b	93 a	91 a
Fluridone	224	1-POST	39 f	85 c	76 c	39 c	100 a	81 c	95 a	80 a
Fluridone	448	1-POST	58 e	84 c	76 c	39 c	100 a	79 c	95 a	78 b
Fluridone	560	1-POST	71 cd	78 c	74 c	23 e	99 a	86 b	98 a	86 a
Fluometuron	1,120	2-POST	88 b	89 b	79 b	40 c	99 a	88 b	100 a	93 a
Fluridone	224	2-POST	96 a	100 a	93 a	96 a	93 a	90 b	93 a	93 a
Fluridone	448	2-POST	85 b	94 b	78 b	94 a	100 a	86 b	93 a	86 a
Fluridone	560	2-POST	79 c	100 a	79 b	93 b	100 a	100 a	95 a	100 a
Fluometuron	1,120	3-POST	83 b	100 a	84 b	100 a	100 a	99 a	96 a	100 a
Fluridone	224	3-POST	78 c	100 a	76 c	100 a	93 a	98 a	91 a	98 a
Fluridone	448	3-POST	86 b	100 a	80 b	99 a	99 a	100 a	95 a	100 a
Fluridone	560	3-POST	36 f	100 a	56 e	100 a	100 a	99 a	99 a	100 a
Fluometuron	1,120	4-POST	93 a	100 a	93 a	100 a	100 a	100 a	100 a	100 a
Fluridone	224	4-POST	95 a	100 a	94 a	100 a	100 a	100 a	100 a	100 a
Fluridone	448	4-POST	98 a	100 a	95 a	100 a	100 a	100 a	100 a	100 a
Fluridone	560	4-POST	90 a	100 a	89 a	100 a	100 a	100 a	99 a	100 a
Contrast										
Fluridone 224 vs. Fluometuron				NS		< 0.0001		NS		NS
Fluridone 336 vs. Fluometuron				0.0003		< 0.0001		NS		NS
Fluridone 448 vs. Fluometuron				< 0.0001		< 0.0001		NS		NS
4-POST vs. 3-POST				NS		NS		NS		NS
4-POST vs. 2-POST				0.0025		< 0.0001		0.0495		NS
4-POST vs. 1-POST				< 0.0001		< 0.0001		0.0007		0.0002
4-POST vs. NO POST				< 0.0001		< 0.0001		< 0.0001		< 0.0001

[z] Means within a column followed by the same lowercase letter are not statistically different based on Fisher's LSD (0.05).

[y] Preemergence herbicides were applied the day of cotton planting.

[x] POST timing applications: (4-POST) glyphosate plus *S*-metolachlor (2-lf) followed by glyphosate plus *S*-metolachlor (4- to 5-lf) followed by glyphosate plus prometryn (8- to 10-lf directed) followed by MSMA plus flumioxazin (Layby directed); (3-POST) glyphosate plus *S*-metolachlor (4- to 5-lf) followed by glyphosate plus prometryn (8- to 10-lf directed) followed by MSMA plus flumioxazin (Layby directed); (2-POST) glyphosate plus prometryn (8- to 10-lf directed) followed by MSMA plus flumioxazin (Layby directed); (1-POST) MSMA plus flumioxazin (Layby directed). See text for rates of each POST herbicide.

Table 4. Seed cotton yield at the Lon Mann Cotton Research Center near Marianna, AR in 2012 and 2013[z,y]

Treatment	Rate	POST application[x]	Control	
			2012	2013
	g ai ha^{-1}		kg ha^{-1}	
Fluometuron	1,120	NO POST	360 c	1,090 b
Fluridone	224	NO POST	360 c	1,660 a
Fluridone	336	NO POST	530 c	1,780 a
Fluridone	448	NO POST	530 c	1,570 a
Fluometuron	1,120	1-POST	390 c	1,540 a
Fluridone	224	1-POST	410 c	1,330 b
Fluridone	336	1-POST	440 c	1,830 a
Fluridone	448	1-POST	390 c	1,280 b
Fluometuron	1,120	2-POST	770 b	1,450 ab
Fluridone	224	2-POST	890 b	1,300 b
Fluridone	336	2-POST	1,120 a	1,720 a
Fluridone	448	2-POST	1,040 a	1,660 a
Fluometuron	1,120	3-POST	1,120 a	1,780 a
Fluridone	224	3-POST	1,040 a	1,570 a
Fluridone	336	3-POST	1,070 a	2,040 a
Fluridone	448	3-POST	860 b	2,010 a
Fluometuron	1,120	4-POST	1,240 a	1,780 a
Fluridone	224	4-POST	1,240 a	1,750 a
Fluridone	336	4-POST	1,100 a	1,750 a
Fluridone	448	4-POST	950 a	1,950 a
	Contrast			
	Fluridone 224 vs. Fluometuron		NS	NS
	Fluridone 336 vs. Fluometuron		NS	0.0305
	Fluridone 448 vs. Fluometuron		NS	NS
	4-POST vs. 3-POST		NS	NS
	4-POST vs. 2-POST		0.0480	NS
	4-POST vs. 1-POST		< 0.0001	0.0419
	4-POST vs. NO POST		< 0.0001	NS

[z] Means within a column followed by the same lowercase letter are not statistically different based on Fisher's LSD (0.05).
[y] Preemergence herbicides were applied the day of cotton planting.
[x] POST timing applications: (4-POST) glyphosate plus *S*-metolachlor (2-lf) followed by glyphosate plus *S*-metolachlor (4- to 5-lf) followed by glyphosate plus prometryn (8- to 10-lf directed) followed by MSMA plus flumioxazin (Layby directed); (3-POST) glyphosate plus *S*-metolachlor (4- to 5-lf) followed by glyphosate plus prometryn (8- to 10-lf directed) followed by MSMA plus flumioxazin (Layby directed); (2-POST) glyphosate plus prometryn (8- to 10-lf directed) followed by MSMA plus flumioxazin (Layby directed); (1-POST) MSMA plus flumioxazin (Layby directed). See text for rates of each POST herbicide.

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