Weed Technology 2012 26:207–212

Effect of Wheat Herbicide Carryover on Double-Crop Cotton and Soybean

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In the southeastern United States many farmers double-crop winter wheat with soybean or cotton. However, there is little information about residual injury of herbicides used in wheat to these rotational crops. Experiments were conducted from 2007 to 2008 and 2008 to 2009 in soft red winter wheat to evaluate response of rotational crops of soybean and cotton after application of various acetolactate synthase herbicides in wheat. Pyroxsulam, mesosulfuron, sulfosulfuron, propoxycarbazone, or chlorsulfuron plus metsulfuron at multiple rates were applied to wheat approximately 110 to 120 d before planting rotational crops. Soils were Tift loamy sand at Ty Ty, GA and Faceville sandy loam at Plains, GA. After wheat harvest, soybean ('Pioneer 97M50') and cotton ('DP 0949 B2RF') were strip-tillage planted and evaluated for injury, stand density, height over time, and yields. For both locations, wheat was tolerant to all herbicide treatments with little to no visible injury 7 to 90 d after application. Pyroxsulam injury was less than sulfosulfuron or mesosulfuron. At recommended use rates, wheat injury was transient with no effect on yield. Double-crop soybean for both locations had no differences in stand establishment for any herbicide treatments. There was significant carryover injury to soybean and cotton for sulfosulfuron applied to wheat for the Faceville sandy loam. There was no effect of herbicide treatment on cotton stand. There was little to no difference in residual activity on rotational crops between pyroxsulam and other wheat herbicides when labeled rates were applied. This is significant as pyroxsulam is used to control Italian ryegrass and wild radish in this region.

Nomenclature: Mesosulfuron; pyroxsulam; propoxycarbazone; sulfosulfuron; cotton, *Gossypium hirsutum* L.; soybean, *Glycine max* Merr. (L.); wheat, *Triticum aestivum* L.
Key words: Herbicide persistence, herbicide carryover, rotational crop injury, bioassay.

En el sureste de los Estados Unidos muchos de los agricultores combinan el cultivo de trigo de invierno con soya o algodón. Sin embargo, existe poca información acerca del daño residual de los herbicidas usados en trigo para estos cultivos en rotación. Se realizaron experimentos de 2007 a 2008 y de 2008 a 2009 en el cultivo de trigo rojo suave de invierno, para evaluar la respuesta de la soya y el algodón como cultivos en rotación después de la aplicación de varios herbicidas ALS en el trigo. Pyroxsulam, mesosulfuron, sulfosulfuron, propoxycarbazone, o chlorsulfuron más metsulfuron a múltiples dosis se aplicaron a este cereal aproximadamente de los 110 a los 120 días antes de sembrar los cultivos en rotación. Los suelos fueron Tift arenoso franco en Ty Ty, GA y Faceville franco arenoso en Plains, GA. Después de la cosecha del trigo, soya (Pioneer 97M50) y algodón (DP 0949 B2RF) fueron sembrados usando labranza en franjas y se evaluó: daño, densidad de plantas, altura a través del tiempo y rendimiento. En ambos sitios, el trigo fue tolerante a todos los tratamientos de herbicida con poco o ningún daño visual entre los 7 y 90 días después de la aplicación (DDA). El daño debido a pyroxsulam fue menor que sulfosulfuron o mesosulfuron. A las dosis recomendadas, el daño al trigo fue transitorio sin tener ningún efecto en el rendimiento. La soya sembrada como cultivo en combinación en ambos sitios, no tuvo diferencias en el establecimiento de las plantas para ninguno de los tratamientos de herbicida. Hubo un daño residual significativo en la soya y en algodón cuando el sulfosulfuron se aplicó al trigo en el suelo franco arenoso en Faceville. No se observó efecto alguno del tratamiento de herbicida en las plantas de algodón. Hubo poca a ninguna diferencia en la actividad residual en los cultivos en rotación entre pyroxsulam y otros herbicidas usados en el trigo cuándo éstos se aplicaron a las dosis recomendadas. Esto es importante ya que pyroxsulam se usa para controlar *Lolium multiflorum y Raphanus raphanistrum* en esta región.

In the southeastern United States, soft red winter wheat is often followed by soybean or cotton in double-cropping systems. All crops receive some level of herbicide application for weed control. This cropping system is widely used and can be profitable to farmers producing two crops in one year (Grey 2007). Herbicides used in wheat to control winter annual species in this region include mesosulfuron, chlorsulfuron plus metsulfuron, pyroxsulam, and propoxycarbazone (Ellis et al. 2010; Grey and Bridges 2003).

DOI: 10.1614/WT-D-11-00143.1

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Pyroxsulam applied POST in wheat will control certain grass and broadleaf weeds (Anonymous 2010a), and is specifically preferred in the southeastern United States because it controls Italian ryegrass (*Lolium multiflorum*) and wild radish (*Raphanus raphanistrum*) (Anonymous 2011). Pyroxsulam is a triazolopyrimidine with reported half-lives of 4.6 d (0–30-cm depth) and 23 d (0–60-cm depth) in a loam and clay loam soil, respectively (EPA 2008). Stable to the abiotic processes of soil photolysis and hydrolysis, pyroxsulam is predicted to be moderately persistent in the environment, but little information about fate in soil is available. The pesticide fact sheet for pyroxsulam lists that the kinetics for field dissipation is uncertain (EPA 2008). Thus, carryover potential to certain crops is unknown, especially in southeastern regions of the United States where cotton can be planted in rotation within 3 mo of wheat herbicide application.

Table 1. Monthly rainfall and cumulative irrigation for wheat herbicide carryover to double-crop cotton and soybean at Plains and Ty Ty, Georgia.

	Plains				Ty Ty			
	2007–2008		2008–2009		2007–2008		2008–2009	
Month	Rainfall	Irrigation	Rainfall	Irrigation	Rainfall	Irrigation	Rainfall	Irrigation
	cm							
February	8.4	0	8.5	0	13.8	0	4.5	0
March	8.1	2.5	19.5	0	8.3	0	24.0	0
April	9.3	1.3	13.0	0	6.2	0	25.4	0
May	4.6	5.3	18.0	3.0	1.8	0	9.9	0
June	7.4	7.6	6.9	3.6	6.0	1.5	4.0	1.5
July	7.0	0	6.7	5.1	8.9	3.0	13.5	1.5
August	29.9	0	17.5	0	27.1	0	19.1	1.5
September	4.1	0	4.2	0	4.8	0	2.5	0
October	9.9	0	13.8	0	15.1	0	10.7	0
Total	105.4		119.8		96.5		118.1	

Other wheat herbicides used in this region also have limited rotational information for cotton. Propoxycarbazone (Anonymous 2010b) is a sulfonylaminocarbonyltriazolinone POST-applied in wheat controlling certain grass and broadleaf weeds, with a half-life of 9 d (Senseman 2007), but reports of a half-life of 54 d were associated with variations in organic matter and soil texture (Rouchaud et al. 2001). Mesosulfuron is a sulfonylurea that is POST-applied to control annual grasses and broadleaf weeds (Anonymous 2010c). It is weakly adsorbed to soil and organic carbon with half-lives of 44 to 75 d (Anonymous 2010d). Sulfosulfuron is a pyrimidinylsulfonylurea that can be applied PRE or POST to control annual and perennial grasses (Anonymous 2010e). It has a variable half-life dependent on climate and soil characteristics, usually 14 to 75 d but can persist 1 to 3 yr (Senseman 2007). Sulfosulfuron is not utilized in wheat in the southeastern region of the United States because of carryover residual activity to double crops, but can be used as a standard in research for comparison (Peeper et al. 2009) with other pyrimidinylsulfonylurea, sulfonylurea, and sulfonamide herbicides. Some soybean cultivars are resistant to these herbicides via genetic selection (Green 2009), but this trait is not in all cultivars and, therefore, these herbicides can injure susceptible plantings. There are currently no cotton cultivars commercially available with acetolactate synthase resistance to the herbicides evaluated in this study.

Sulfonlyurea herbicides generally degrade more slowly in alkaline and low-organic-matter soils (Maheswari and Ramesh 2007). Georgia and other southeastern states of Alabama, South Carolina, and Florida have temperate climates, and although freezing air temperatures are common, soil temperatures seldom drop below or remain at freezing during winter months (Hoogenboom 2011). This type of soil environment should be conducive to rapid herbicide dissipation, but differences in herbicide chemistry can result in varied carryover potential.

There is limited information available for pyroxsulam soil degradation and half-life. Crop rotation information for cotton and soybean is limited. Given the variability in wheat herbicide persistence, studies were designed to evaluate the effects of these herbicides on wheat tolerance and yield when applied in winter on two different soil types, loamy sand and sandy clay loam. Soybean and cotton tolerance were evaluated as rotational double crops to determine any detrimental effects.

Materials and Methods

Experiments were conducted from 2007 to 2008 and 2008 to 2009 in different areas of the same field at the Southwest Georgia Branch Experiment Station located near Plains and at the Ponder Research Station at Ty Ty, Georgia. Soil types were a Faceville sandy loam (clayey, kaolinitic, thermic, Typic Kandiudults) with 1.6% organic matter and pH 5.9 to 6.1 at Plains, and Tifton loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) with 1.0% organic matter and pH 6.0 to 6.2 at Ty Ty. All soils were disk harrowed and moldboard plowed 25 to 30 cm deep, then rotary tilled. Single plots were 3.6 m wide and 9.1 m long at Plains and 3.6 m wide and 7.6 m long at Ty Ty in 2007 to 2008. Wheat ('AGS 2000') was sown into seedbeds on November 16, 2007 at Plains, December 21, 2007 at Ty Ty, November 19, 2008 at Plains, and November 18, 2008 at Ty Ty. The cultivar AGS 2000 (Johnson et al. 2002) was planted at 112 kg ha^{-1} for all experiments. Herbicide treatments were applied February 11, 2008 and February 12, 2009 at Plains, and February 8, 2008 and February 11, 2009 at Ty Ty when wheat was in Feekes' stage 4 to 5. Herbicides were applied with a CO_2-pressurized sprayer calibrated to deliver 140 L ha^{-1} at 172 kPa. Total rainfall and irrigation for the period after herbicide application were recorded (Table 1) (Hoogenboom 2011).

Experimental design each year was a randomized complete block with four replications. Complete treatment descriptions are listed in Tables 2 and 3. Treatments were applied approximately 110 to 120 d before planting rotational crops. For the 2007-to-2008 study, pyroxsulam was applied to wheat at 19, 37, or 74 g ai ha^{-1}; propoxycarbazone at 44 or 88 g ai ha^{-1}; mesosulfuron at 15 or 30 g ai ha^{-1}; and sulfosulfuron at 35 or 70 g ai ha^{-1}. For the 2008-to-2009 study, pyroxsulam was applied to wheat at 19, 37, or 74 g ai ha^{-1}; chlorsulfuron plus metsulfuron at 22 plus 5, 44 plus 9, or 88 plus 18 g ai ha^{-1}; mesosulfuron at 15 or

https://doi.org/10.1614/WT-D-11-00143.1 Published online by Cambridge University Press

Table 2. Effect of herbicide treatment on wheat yield, cotton, and soybean double-crop response in Georgia in 2007 to 2008.

		Wheat yield		Soybean					Cotton	
				Stand		Height		Yield	Stand	Height
Treatment[a]	Rate	Ty Ty	Plains	Ty Ty	Plains	Ty Ty	Plains	Ty Ty	Plains	Plains
	g ai ha^{-1}	kg ha^{-1}		# (m row)$^{-1}$		cm plant^{-1}		kg ha^{-1}	# (m row)$^{-1}$	cm plant^{-1}
Pyroxsulam	19	3,250 a[b]	5,110 ab	13.3 a	14.3 a	17.4 a	32.1 a	1,780 a	8.0 a	44.2 a
	37	3,070 a	4,880 ab	11.8 a	13.7 a	16.3 a	31.5 a	2,050 a	7.7 a	38.5 a
	74	3,560 a	4,570 b	11.5 a	13.3 a	16.7 a	32.6 a	1,850 a	8.0 a	41.4 a
Propoxycarbazone	44	3,270 a	5,190 a	10.4 a	13.7 a	17.2 a	31.5 a	1,890 a	8.3 a	44.3 a
	88	2,930 a	5,030 ab	10.8 a	15.3 a	15.7 a	27.8 ab	2,010 a	8.3 a	37.3 a
Mesosulfuron	15	3,230 a	4,790 ab	11.2 a	13.0 a	17.2 a	27.8 ab	2,160 a	7.7 a	37.7 a
	30	3,190 a	5,040 ab	12.0 a	14.7 a	17.8 a	28.9 ab	2,100 a	8.0 a	37.8 a
Sulfosulfuron	35	3,550 a	5,070 ab	12.0 a	12.0 a	17.6 a	28.1 ab	1,750 a	–	–
	70	3,670 a	5,070 ab	11.9 a	12.7 a	17.4 a	22.6 b	2,030 a	7.3 a	32.1 a
Nontreated	–	3,850 a	5,020 ab	11.0 a	15.0 a	17.2 a	28.9 ab	2,060 a	8.0 a	37.9 a

[a] Herbicides applied to wheat in Feekes' stage 4 to 5 on February 8 and 11, 2008, with soybean and cotton planted June 13 and 6 2008 at Ty Ty and Plains, respectively.

[b] Means within a column followed by the same letter are not significantly different from each other according to Fisher's Protected LSD test at $P \leq 0.05$.

30 g ai ha^{-1}; and sulfosulfuron at 35 or 70 g ai ha^{-1}. After wheat harvest, soybean ('Pioneer 97M50RR') and cotton ('DP 0949 B2RF') were planted with two rows of each, 1.8-m-wide by 9.1-m-long plots at Plains and 1.8 m wide by 7.6 m long at Ty Ty. Cotton was not planted at Ty Ty for the 2007–2008 experiment. All seed were planted at 1.5 cm deep with soybean at approximately 12 to 16 seed m^{-1} of row, and cotton at 7 to 10 seed m^{-1} of row using a Monosem (ATI, Inc., Lenexa, KS) precision vacuum planter. Emergence occurred within 5 d after planting. For Plains, double crops were planted June 6, 2008 and June 2, 2009 and for Ty Ty June 13, 2008 and June 1, 2009. On the day of double-crop planting, land preparation was performed using a Brown strip-till implement (Brown Manufacturing Co., Ozark, AL). Rows were ripped with a single subsoiler shank, in tandem with fluted coulters to break up large clods, along with rolling crumblers that served to smooth the seedbed. Strip-tillage rows were ripped 8 cm deep and 20 cm wide with 0.9 m between row centers. Approximately 50% of the surface residues remained after the strip tillage operation was performed. Standard culture practices for wheat, soybean, and cotton production were followed using University of Georgia recommendations for fertilizer and insect control (Anonymous 2011). Summer crops were maintained weed free via hand weeding and as-needed glyphosate applications.

Crop injury (wheat, soybean, and cotton) was visually estimated on a scale of 0 (no injury) to 100% (death). Soybean and cotton were evaluated for stand establishment (number [m row]$^{-1}$) and height (cm) measurement four times during June and July at 125- to 127-, 133- to 135-, 144- to 153-, and 159-d intervals after herbicide applications. All grain was harvested using a small plot combine, and cotton with a spindle picker, and then final yields determined. Soybean and cotton harvests were not made for the 2007-to-2008 Plains study because of weather-related problems.

All data were subjected to mixed-model ANOVA. Since different herbicides were used for the two different years and soil types were different for each location, all data were analyzed and presented separately. Percentage data were arcsine-square-root transformed to improve normality before analysis. Means were separated using Fisher's Protected LSD at the $P \leq 0.05$ level. Data were back-transformed for presentation. Since there were varying numbers of treatments for each herbicide, data could not be analyzed with regression.

Results and Discussion

There were differences for environmental measures taken during the course of each experiment. However, all experiments were conducted at times when herbicide applications could normally occur in Georgia wheat production and are thus representative of producer practices. Cumulative rainfall and irrigation ranged from 96 to 120 cm between the time of herbicide application and double-crop harvest (Table 1), which are representative for the region.

Wheat. Wheat injury ranged from 0 to 12% across treatments and years for all herbicides (data not shown). Wheat injury

Table 3. Effect of herbicide treatment on wheat yield and double-crop soybean response in Georgia from 2008 to 2009.

				Soybean					
		Wheat yield		Stand		Height		Yield	
Treatment[a]	Rate	Ty Ty	Plains	Ty Ty	Plains	Ty Ty	Plains	Ty Ty	Plains
	g ai ha^{-1}	kg ha^{-1}		# (m row)$^{-1}$		cm plant^{-1}		kg ha^{-1}	
Pyroxsulam	19	2,010 a[b]	5,170 bc	14.3 a	14.8 a	38.2 a	30.1 ab	2,410 ab	4,140 ab
	37	2,410 a	5,350 a–c	14.5 a	15.3 a	39.9 a	32.9 a	2,870 a	4,270 ab
	74	2,460 a	5,090 c	12.0 a	14.0 a	40.2 a	31.3 ab	2,760 a	4,240 ab
Chlorsulfuron plus	22 + 5	2,270 a	5,510 a–c	15.3 a	16.5 a	34.4 ab	33.0 a	2,610 ab	4,220 ab
metsulfuron	44 + 9	2,070 a	5,520 a–c	13.8 a	14.5 a	24.7 a–c	22.6 b–d	2,340 ab	3,920 a–c
	88 + 18	1,940 a	5,260 a–c	11.8 a	11.0 a	11.4 c	18.6 cd	740 c	3,390 bc
Mesosulfuron	15	1,920 a	5,530 ab	14.3 a	14.3 a	39.4 a	32.4 a	2,910 a	4,300 a
	30	2,260 a	5,330 ab	12.8 a	13.0 a	42.2 a	32.5 a	3,140 a	4,390 a
	60	2,410 a	5,230 a–c	14.8 a	12.8 a	37.5 a	32.5 a	2,780 a	4,170 ab
Sulfosulfuron	35	1,740 a	5,620 ab	12.8 a	12.3 a	31.3 a–c	22.3 b–d	2,560 ab	3,840 a–c
	70	1,810 a	5,660 a	12.3 a	11.0 a	14.7 c	13.0 d	1,220 bc	3,080 c
Nontreated	–	2,090 a	5,630 ab	14.3 a	17.3 a	37.5 a	31.7 ab	3,140 a	4,200 ab

[a] Herbicides applied to wheat in the Feekes' stage 4 to 5 on February 11 and 12 2009, with soybean planted June 1 and 2 2009 at Ty Ty and Plains, respectively.
[b] Means within a column followed by the same letter are not significantly different from each other according to Fisher's Protected LSD test at $P \leq 0.05$.

was transient and not evident by harvest and has been previously noted for these herbicides (Ellis et al. 2010; Grey and Bridges 2003; Khodayari et al. 1985). Wheat yield varied by location and by year (Tables 2 and 3). Pyroxsulam at 74 g ai ha^{-1} reduced wheat yield at Plains in 2008 and 2009 as compared with the nontreated controls; however, this application rate was four times the registered rate of 18.4 g ai ha^{-1}. Previous research has indicated no differences for wheat yield for these herbicides (Bailey and Wilson 2003; Bond et al. 2005; Kelley and Peeper 2003). Wheat yield at Ty Ty for the 2008-to-2009 wheat trial were lowest for all studies, possibly due to rainfall (Table 1), which caused nitrogen loss that limited yield.

Rotational Crop Response. There were no differences for final stand establishment for double-crop soybean or cotton for any herbicide carryover treatment as compared with the nontreated control for any location or experiment within (Tables 2, 3, and 4). Initial seedling emergence varied by experiment for cotton and soybean, but there was never any significant effect of herbicide treatment as compared with the nontreated control, indicating that none of the wheat herbicides limited seed germination. Similar data have indicated no reduction in stand for rotational-cropped barley, pea, mustard, and lentil when sulfosulfuron was applied in winter wheat (Shinn et al. 1998).

Soybean height varied in response to herbicide treatment. For the 2007-to-2008 herbicide carryover experiment at Ty Ty, soybean heights were not different for any measurements taken at150 d (data not shown) or 159 d after treatment (Table 2). In contrast, injury to soybean reduced plant height in the 2007-to-2008 experiment at Plains. Sulfosulfuron at 70 g ha^{-1} applied to wheat resulted in reduced soybean height, although not different from the nontreated control. Pyroxsulam at 74 g ha^{-1} did not cause carryover injury, with soybean height averaging 32.6 cm per plant, which was similar to the nontreated control of 28.9 cm per plant. Mesosulfuron did not affect soybean height as compared with the nontreated control.

For the 2008-to-2009 studies at Ty Ty and Plains, chlorsulfuron plus metsulfuron at 88 plus 18 g ha^{-1} respectively, and sulfosulfuron at 70 g ha^{-1} decreased soybean height significantly compared with the nontreated control (Table 3). Injury has been previously noted in carryover experiments for soybean with chlorsulfuron at 75 g ha^{-1} (Khodayari et al. 1985). Pyroxsulam and mesosulfuron at any rate did not affect soybean height, indicating the crop safety for these two herbicides with respect to double-crop systems when used in wheat followed by double-crop soybean.

Soybean yield for the 2007-to-2008 study at Ty Ty was not affected by any wheat residual herbicide (Table 2). In contrast, some of the residual herbicides negatively affected soybean yield following the same trend as for height reduction for chlorsulfuron plus metsulfuron and sulfosulfuron for Ty Ty and Plains in 2008 to 2009 (Table 3). Khodayari et al. (1985) reported similar soybean yield reduction for chlorsulfuron applied in wheat. Soybean yields following pyroxsulam or mesosulfuron were not significantly different from the nontreated control at these two locations.

Cotton height at Plains in 2007 to 2008 was not significantly different for any herbicide wheat treatment as compared with the nontreated control (Table 2). Pyroxsulam, mesosulfuron, and sulfosulfuron cotton height was not significantly different from the nontreated control in 2008 to 2009 for Ty Ty or Plains, indicating that there was no carryover effect (Table 4). Chlorsulfuron plus metsulfuron at the highest rate significantly reduced cotton height, indicating carryover. Yield was significantly reduced for this treatment at Ty Ty when compared with the nontreated control.

Herbicide dissipation mechanisms for these herbicides will affect carryover potential. There was no effect on double-crop yield for cotton or soybean when pyroxsulam was applied to winter wheat as compared with the nontreated control at Plains for the Faceville sandy clay loam or Ty Ty for the Tifton loamy sand. Additionally, irrigation and rainfall for all four experiments exceeded 96 cm at each site-year location. There are differences for sulfonylurea herbicide dissipation, which is an intricate process involving soil pH, soil texture,

Table 4. Effect of herbicide treatment on double-crop cotton response in Georgia in 2008 to 2009.

		Cotton					
		Stand		Height		Yield	
Treatment[a]	Rate	Ty Ty	Plains	Ty Ty	Plains	Ty Ty	Plains
	g ai ha^{-1}	# (m row)$^{-1}$		cm plant^{-1}		kg ha^{-1}	
Pyroxsulam	19	8.5 a[b]	5.5 a	56.1 ab	41.0 ab	2,560 a	3,880 ab
	37	8.3 a	5.5 a	60.2 a	44.4 a	2,760 a	4,120 a
	74	8.9 a	5.5 a	54.2 ab	41.0 ab	2,910 a	4,200 a
Chlorsulfuron plus metsulfuron	22 + 5	9.5 a	6.3 a	44.5 ab	41.7 ab	2,330 ab	4,050 ab
	44 + 9	9.3 a	6.8 a	36.1 bc	38.8 b	2,360 ab	3,950 ab
	88 + 18	10 a	5.8 a	15.2 c	28.7 c	1,310 c	3,280 b
Mesosulfuron	15	8.5 a	8.0 a	62.5 a	48.1 a	2,890 a	4,140 ab
	30	7.8 a	7.0 a	58.6 a	44.7 ab	2,910 a	4,030 ab
	60	8.5 a	6.5 a	55.6 ab	42.6 ab	2,700 a	4,040 ab
Sulfosulfuron	35	8.0 a	7.0 a	57.5 ab	43.3 ab	2,260 ab	4,200 a
	70	9.5 a	6.5 a	55.4 ab	43.7 ab	2,320 ab	3,840 ab
Nontreated	–	8.3 a	6.5 a	59.5 a	44.9 ab	2,490 a	3,870 ab

[a] Herbicides applied to wheat in the Feekes' stage 4 to 5 on February 8 and 11 2008; cotton was planted June 1 and 2 2008 at Ty Ty and Plains, respectively.

[b] Means within a column followed by the same letter are not significantly different from each other according to Fisher's Protected LSD test at $P \leq 0.05$.

and organic matter. Sarmah and Sabadie (2002) noted that several researchers reported a negative relationship between sorption and soil pH, with decreased sorption with increased soil pH for sulfonylurea herbicides. As previously noted, these herbicides all have variable half-lives and soil reactivity. Sulfosulfuron dissipation has been reported to be slower in an Inceptisol with pH 7.2 as compared with an Alfisol with pH 4.0, with both soils exhibiting first-order rate kinetics and sulfosulfuron hysteresis (Maheswari and Ramesh 2007). As the pH for these current experiments was 5.9 to 6.2, the potential for extended residual activity should be limited to chlorsulfuron plus metsulfuron, which was observed for the soybean and cotton field bioassay. Overall, pyroxsulam and mesosulfuron were similar, indicating their crop safety with respect to double-cropping systems in the southeastern United States.

In conclusion, these herbicides utilized in wheat, chlorsulfuron plus metsulfuron, sulfosulfuron, mesosulfuron, and pyroxsulam, had variable carryover with respect to double-crop cotton and soybean. Pyroxsulam provides a wide spectrum of wheat weed control and has been rapidly adopted by southeastern U.S. wheat producers for POST control of Italian ryegrass and wild radish. Mesosulfuron is also being used to control Italian ryegrass and other weeds. Sulfosulfuron, propoxycarbazone, and chlorosulfuron plus metsulfuron have label restrictions that prevent the rotation of cotton or conventional soybean within 12 mo of application because of injury potential associated with carryover, and these experiments confirm those recommendations. Pyroxsulam and mesosulfuron did not carry over to adversely affect double-crop cotton or soybean when used in accordance with the label registration, with no negative effects even at rates greater than registered.

Acknowledgments

The authors thank Charlie Hilton, Jess Parker, George Cutts, III, Rebekah Wallace, and Ronnie Pines for technical support. Financial support was provided by Dow AgroSciences and the University of Georgia. The University of Georgia Coastal Plain Experiment Station and Southwest Georgia Experiment Station provided support, land, and irrigation for crop production.

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Received September 29, 2011, and approved January 3, 2012.