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Postemergence Yellow Nutsedge Management in Sweetpotato

Stephen L. Meyers and Mark W. Shankle*

Field studies were conducted in 2013 at Houlka, MS and in 2014 at Houston, MS to evaluate herbicide programs for yellow nutsedge control and sweetpotato crop response. Treatments consisted of halosulfuron-methyl at 13, 26, and 34 g ai ha^{-1} 2 wk after transplanting (WAP) followed by (fb) *S*-metolachlor at 856 g ai ha^{-1} 4 WAP; a sequential application of 13 g ha^{-1} halosulfuron-methyl at 2 and 4 WAP; and halosulfuron-methyl at 13 g ha^{-1} plus either *S*-metolachlor or 1,123 g ai ha^{-1} alachlor 2 WAP. Crop injury in treated plots ranged from 29 to 44% at 3 WAP. Injury from the sequential application increased slightly between 3 and 5 WAP (29 to 38%), but decreased between 5 WAP and harvest (19%). Injury with all other treatments was unchanged from 5 WAP through harvest. The sequential application of halosulfuron-methyl provided the greatest control of yellow nutsedge throughout the duration of the study with ≥ 83% control from 5 WAP through harvest. Control from all other treatments ranged from 38 to 78% from 5 WAP through harvest. No. 1, canner, and marketable sweetpotato yields of the hand-weeded check were 19,900; 7,140; and 27,590 kg ha^{-1}, respectively. No. 1, canner, and marketable yields of the weedy check were only 15, 51, and 25% of the hand-weeded check, respectively. With the exception of halosulfuron-methyl at 13 g ha^{-1} fb *S*-metolachlor, which was similar to the weedy check, no. 1 and marketable yields with all treatments were greater than the weedy check, but less than the weed-free check. A sequential application of halosulfuron-methyl and a tank mix of halosulfuron-methyl plus *S*-metolachlor would fit well into an overall yellow nutsedge management program in sweetpotato. However, as halosulfuron-methyl is not registered for use in sweetpotato, growers must continue to manage yellow nutsedge primarily with crop rotation and sanitation.
Nomenclature: Alachlor; halosulfuron-methyl; *S*-metolachlor; yellow nutsedge, *Cyperus esculentus* L.; sweetpotato, *Ipomoea batatas* L. Lam. 'Beauregard'.
Key words: Crop tolerance, herbicide rate, sequential herbicide application, tank mix.

Se realizaron experimentos de campo en 2013 en Houlka, Mississippi, y en 2014 en Houston, Mississippi, para evaluar programas de herbicidas para el control de *Cyperus esculentus* y la respuesta del cultivo batata. Los tratamientos consistieron en halosulfuron-methyl a 13, 26, y 34 g ai ha^{-1} 2 semanas después del trasplante (WAP) seguido de (fb) *S*-metolachlor a 856 g ai ha^{-1} 4 WAP; una aplicación secuencial de 13 g ha^{-1} de halosulfuron-methyl a 2 y 4 WAP; y halosulfuron-methyl a 13 g ha^{-1} más *S*-metolachlor o 1,123 g ai ha^{-1} de alachlor 2 WAP. El daño en el cultivo en las parcelas tratadas varió de 29 a 44% a 3 WAP. El daño de la aplicación secuencial aumentó ligeramente entre 3 y 5 WAP (29 a 38%), pero decreció entre 5 WAP y la cosecha (19%). El daño causado por todos los demás tratamientos se mantuvo sin cambios en el período entre 5 WAP y la cosecha. La aplicación secuencial de halosulfuron-methyl brindó el mayor control de *C. esculentus* durante la duración del estudio con ≥83% de control entre 5 WAP y la cosecha. El control con los otros tratamientos varió de 38 a 78% entre 5 WAP y la cosecha. Los rendimientos No. 1, para enlatado, y comercializable de la batata en el testigo con deshierba manual fueron 19,900; 7,140; y 27,590 kg ha^{-1}, respectivamente. Los rendimientos No. 1, para enlatado, y comercializable del testigo sin deshierba fueron solamente el 15, 51, y 25% en comparación con el testigo con deshierba manual. Con la excepción de halosulfuron-methyl a 13 g ha^{-1} fb *S*-metolachlor, el cual fue similar al testigo sin deshierba, los rendimientos No. 1 y comercializable de todos los demás tratamientos fueron mayores al testigo sin deshierba, pero fueron menores al testigo libre de malezas. Una aplicación secuencial de halosulfuron-methyl y una mezcla en tanque de halosulfuron-methyl más *S*-metolachlor calzaría bien dentro de un programa general de manejo de *C. esculentus* en batata. Sin embargo, como halosulfuron-methyl no está registrado para uso en batata, los productores deben continuar manejando *C. esculentus* principalmente con rotación de cultivos y medidas sanitarias.

In 2012, Mississippi sweetpotato producers planted 8,970 ha with an average yield of 17,930 kg ha^{-1} (USDA-NASS 2014). Sweetpotato production provides Mississippi with an estimated $132 million of direct and indirect value annually (Morgan et al. 2012). Yellow nutsedge is among the most troublesome weeds in row crop production systems in the southern United States (Webster and Nichols 2012), including sweetpotato production

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(Webster 2014). Season-long yellow nutsedge interference can reduce total marketable sweetpotato yield 6 to 80% at densities of 5 to 90 shoots m^{-2}, respectively (Meyers and Shankle 2015).

Management strategies to control yellow nutsedge in sweetpotato are limited. Currently *S*-metolachlor is the only herbicide registered for use in sweetpotato that will control or suppress yellow nutsedge if an activating rainfall occurs before nutsedge emergence (Shankle et al. 2014). However, *S*-metolachlor applications made immediately after transplanting and followed by a moderate to heavy rainfall event can result in crop injury and unacceptable levels of yield and quality losses (Meyers et al. 2010, 2012, 2013a,b). For that reason, many growers have opted to delay *S*-metolachlor applications, as crop tolerance increases from 0 to 14 d after transplanting (DAP) (Meyers et al. 2010, 2013b). There is a risk that yellow nutsedge will emerge before a delayed *S*-metolachlor application can be made. Though growers cultivate sweetpotato fields multiple times a season (Haley and Curtis, unpublished data), cultivation does little to control weeds in the planted row. Hand removal is often used to control many weed species in sweetpotato (Haley and Curtis, unpublished data); however, hand removing yellow nutsedge is impractical given its low meristematic growing point and subterranean rhizomes and tubers. Sweetpotato growers have expressed an interest in using halosulfuron-methyl POST to control yellow nutsedge. Halosulfuron-methyl received a Section 18 emergency exception label in Louisiana and Mississippi in 2004 and in North Carolina in 2005 for this purpose.

Sweetpotato tolerance to halosulfuron-methyl has been studied in previous trials. MacRae et al. (2007) applied halosulfuron-methyl at 13 to 65 g ha^{-1} 1, 2, 3, or 4 wk after transplanting (WAP) and reported that an application at 4 WAP did not reduce no. 1 or total yields of 'Beauregard' and 'Hernandez'. However, applications made sooner than 4 WAP reduced no. 1 and total yields. Dittmar et al. (2013) reported that total yield of Beauregard and 'Covington' sweetpotato decreased linearly from 0 to 52 g ha^{-1} halosulfuron-methyl across application timings of 10, 22, and 31 DAP. Covington displayed greater storage root injury than Beauregard, and applications made 22 and 31 DAP to Covington resulted in unacceptable incidence of black blistering on the skin and red-brown spots on the flesh (Dittmar et al. 2013).

Though sweetpotato tolerance to halosulfuron-methyl has been reported, there is little published data regarding the influence of the herbicide in a POST nutsedge management program in sweetpotato. Studies conducted by MacRae et al. (2007) and Dittmar et al. (2013) were conducted in fields that were maintained weed free. To determine how halosulfuron-methyl fits into a yellow nutsedge management program, weed control efficacy and sweetpotato yield with different rates and application timings need to be investigated. The objectives of this research were to determine the influence of POST halosulfuron-methyl-based management programs on yellow nutsedge control and sweetpotato tolerance, yield, and quality.

Materials and Methods

Studies were conducted in commercial fields in Houlka, MS in 2013 and Houston, MS in 2014. Beauregard sweetpotato slips (shoot tip cuttings), each 30 cm long, were mechanically transplanted 30 cm apart into ridged rows spaced 1 m apart on June 5, 2013 and June 20, 2014 into an Adaton silt loam (fine-silty, mixed, thermic Typic Ochraqualfs) with pH 6.3 and 0.7% organic matter and a Falkner silt loam (fine-silty, siliceous, thermic Aquic Paledualfs) with pH 4.8 and 0.9% organic matter, respectively. Plot size was three rows wide and 5.5 m long in 2013 and 6 m long in 2014. The first row of each plot was nontreated and served as a border row; the second and third rows were treated. The Houlka location received 109 g ai ha^{-1} flumioxazin (Valor® SX, Valent USA Corp., Walnut Creek, CA) pretransplanting. Both locations received 841 g ai ha^{-1} clomazone (Command® 3ME, FMC Corporation, Philadelphia, PA 19103) within 48 h after transplanting and were cultivated between rows with a rolling cultivator 2 WAP, immediately before the application of treatments. Yellow nutsedge was the predominant weed at both locations. When additional weed species emerged, they were hand removed weekly.

Treatments consisted of halosulfuron-methyl (HaloMax75™, Aceto Agricultural Chemicals Corp., Port Washington, NY) at 13, 26, and 34 g ai ha^{-1} 2 WAP followed by (fb) *S*-metolachlor (Dual Magnum®, Syngenta Crop Protection, Inc.,

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Table 1. Influence of POST treatments on crop injury and yellow nutsedge control averaged across both Houlka (2013) and Houston (2014).

Treatment			Crop injury (WAP[a])			CYPES control (WAP)		
Herbicide	Rate	Timing	3	5	7	5	7	17
	g ai ha^{-1}	WAP	%					
Hand-weeded check			0	0	0	100	100	100
Weedy check			0	0	0	0	0	0
Halosulfuron-methyl fb	13	2	29	38	23	83	95	85
Halosulfuron-methyl	13	4						
Halosulfuron-methyl + *S*-metolachlor	13 + 856	2	37	11	13	69	78	69
Halosulfuron-methyl fb	13	2	31	15	18	51	43	38
S-metolachlor	856	4						
Halosulfuron-methyl fb	26	2	42	23	15	63	63	72
S-metolachlor	856	4						
Halosulfuron-methyl fb	34	2	44	26	30	70	63	63
S-metolachlor	856	4						
Halosulfuron-methyl + alachlor	13 + 1,123	2	34	10	13	61	59	46
LSD ($P \leq 0.05$)			10	10	17	19	15	18

[a] Abbreviations: WAP, wk after transplanting; fb, followed by.

Greensboro, NC) at 856 g ai ha^{-1} 4 WAP; a sequential application of 13 g ha^{-1} halosulfuron-methyl at 2 and 4 WAP; and halosulfuron-methyl at 13 g ha^{-1} plus either 856 g ha^{-1} *S*-metolachlor or 1,123 g ai ha^{-1} alachlor (Intrro®, Monsanto Company, St. Louis, MO) 2 WAP. All halosulfuron-methyl applications included 1% (v/v) methylated seed oil (MSO). Weedy and hand-weeded checks were included for purposes of comparison. Treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 140 L ha^{-1} at 160 kPa and fitted with two 8002 XR nozzle tips (Teejet 8002 XR, Teejet Technologies, Springfield, IL). The experiment design was a randomized complete block with four replications.

Foliar sweetpotato injury and yellow nutsedge control were visually evaluated 3, 4, 5, 7, and 17 WAP using a scale of 0 (no crop injury, no weed control) to 100% (crop death, complete weed control). Sweetpotato storage roots were harvested from the two treated rows 119 and 122 DAP in 2013 and 2014, respectively, using a tractor-mounted chain digger. Storage roots were hand graded into jumbo ($\geq$ 8.9 cm in diameter), no. 1 ($\geq$ 4.4 cm but $<$ 8.9 cm), canner ($\geq$ 2.5 cm but $<$ 4.4 cm), and cull (misshapen roots) (USDA 2005) and weighed. Total marketable yield was calculated as the sum of jumbo, no. 1, and canner grades.

Data were subjected to ANOVA and analyzed by SAS (SAS/STAT® 9.3, SAS Institute Inc., Cary, NC) Proc Mixed with the fixed effect of treatment and random effects of year and replication within year. When ANOVA indicated a significant treatment effect, means were separated by Fisher's protected LSD. Arcsine square-root-transformed data were analyzed for visual sweetpotato injury and yellow nutsedge control ratings, and presented as untransformed data for discussion purposes. The weedy and hand-weeded checks were included in yield analysis. However, crop injury and yellow nutsedge control data from the checks were not included in data analysis.

Results and Discussion

Because of a lack of treatment-by-location interaction, data for sweetpotato injury, nutsedge control, and sweetpotato yield were combined across both locations.

Sweetpotato Injury. Sweetpotato crop injury, a general chlorosis followed by stunting, in treated plots ranged from 29 to 44% 3 WAP (Table 1). Injury trends observed at 4 WAP were similar to those observed at 3 WAP and ranged from 29 to 53% (data not shown). With the exception of the sequential application of 13 g ha^{-1} halosulfuron-methyl at 2 and 4 WAP, crop injury decreased between 3 and 5 WAP. Injury from the sequential

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Table 2. Influence of POST treatments on sweetpotato yield by grade averaged across both Houlka (2013) and Houston (2014).

Treatment			Sweetpotato yield				
Herbicide	Rate	Timing	Jumbo	No. 1	Canner	Marketable	Cull
	g ai ha^{-1}	WAP[a]	kg ha^{-1}				
Hand-weeded check			550	19,900	7,140	27,590	740
Weedy check			250	3,020	3,670	6,940	110
Halosulfuron-methyl fb	13	2	130	11,530	7,040	18,700	640
Halosulfuron-methyl	13	4					
Halosulfuron-methyl + *S*-metolachlor	13 + 856	2	430	11,300	6,760	18,490	1,000
Halosulfuron-methyl fb	13	2	0	6,930	4,720	11,650	370
S-metolachlor	856	4					
Halosulfuron-methyl fb	26	2	190	10,120	6,000	16,310	930
S-metolachlor	856	4					
Halosulfuron-methyl fb	34	2	150	9,980	5,400	15,530	660
S-metolachlor	856	4					
Halosulfuron-methyl + alachlor	13 + 1,123	2	150	9,240	6,550	15,940	400
LSD ($P \leq 0.05$)			NS	4,090	1,980	5,620	560

[a] Abbreviations: WAP, wk after transplanting; fb, followed by.

application increased between 3 WAP and 5 WAP (29 to 38%). This increased injury was the result of a sequential halosulfuron-methyl application made at 4 WAP. Injury from the sequential halosulfuron-methyl applications decreased with each rating from 5 WAP to harvest. Injury in all other treatments remained relatively unchanged from 5 WAP through harvest. Halosulfuron-methyl at 34 g ha^{-1} fb *S*-metolachlor consistently resulted in greater crop injury than halosulfuron-methyl at 13 g ha^{-1} fb *S*-metolachlor. However, crop injury from halosulfuron-methyl at 13 g ha^{-1} fb *S*-metolachlor was similar to halosulfuron-methyl at 26 g ha^{-1} fb *S*-metolachlor.

Yellow Nutsedge Control. The sequential application of 13 g ha^{-1} halosulfuron-methyl at 2 and 4 WAP provided the greatest control of yellow nutsedge throughout the duration of the study and $\geq$ 83% control from 5 WAP through harvest (Table 1). When halosulfuron-methyl was applied at the lowest rate used in the study (13 g ha^{-1}), a tank mix with *S*-metolachlor applied 2 WAP provided greater yellow nutsedge control (69 to 78%) at 7 and 17 WAP than applying the two herbicides separately at 2 and 4 WAP, respectively (38 to 51%). The tank mix of halosulfuron-methyl at 13 g ha^{-1} plus *S*-metolachlor 2 WAP also provided greater yellow nutsedge control 7 and 17 WAP than 13 g ha^{-1} halosulfuron-methyl plus alachlor 2 WAP ($\leq$ 59%) and equivalent control to halosulfuron-methyl at 26 or 34 g ha^{-1} 2 WAP fb *S*-metolachlor 4 WAP. When halosulfuron-methyl and *S*-metolachlor were applied separately at 2 and 4 WAP, respectively, halosulfuron-methyl at 26 and 34 g ha^{-1} provided greater control at 7 and 17 WAP than 13 g ha^{-1}.

Sweetpotato Yield. With the exception of halosulfuron-methyl at 13 g ha^{-1} fb *S*-metolachlor, which was similar to the weedy check and provided limited season-long nutsedge control (38%), all treatments had no. 1 and marketable yields greater than the weedy check, but less than the weed-free check (Table 2). Similar no. 1 and marketable yield losses due to yellow nutsedge interference were reported by Meyers and Shankle (2015). Given the treatment set used in the present study, the researchers cannot objectively attribute sweetpotato yield loss to injury from herbicide application or yellow nutsedge interference from nutsedge shoots not controlled by treatment. However, there was a yield increase when most treatments were applied, attributed to yellow nutsedge control.

Crop injury in the present study differed from reports of previous researchers. MacRae et al. (2007) reported that halosulfuron-methyl applied 2 and 4 WAP resulted in 15 and 14% injury 2 wk after treatment (WAT) and 9 and 14% 8 WAP, respectively. Halosulfuron-methyl treatments applied at 2 WAP in the present study resulted in 29 to 53% injury 2 WAT and 13 to 30% injury 7 WAP. Though Dittmar et al. (2013) reported greater crop injury than MacRae (35% at 1 WAT),

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the researchers reported that injury was transient and 0% by 3 WAT. Injury in the present study was more persistent and remained $\geq$ 13% through harvest for all treatments containing halosulfuron-methyl.

Differences in crop response can occur for many reasons. In the present study halosulfuron-methyl was applied with 1% MSO, whereas MacRae et al. (2007) and Dittmar et al. (2013) used 0.25% nonionic surfactant (NIS). MSO was used in the study in an effort to maximize halosulfuron-methyl activity and yellow nutsedge control. Knezevic et al. (2009) reported that MSO improved saflufenacil activity on several winter annual broadleaf weeds more than crop oil concentrate (COC) and NIS. Similarly Tonks and Eberlein (2001) reported that at lower rimsulfuron rates, MSO provided greater weed control in potato (*Solanum tuberosum* L.) than COC or NIS. The persistence of crop injury in the present study may also be the result of including *S*-metolachlor. Previously, researchers have reported that when *S*-metolachlor is applied alone to sweetpotato at 2 WAP, there is no visible stunting injury (Meyers et al. 2012) or transient injury $\leq$ 10% (Meyers et al. 2013b). The authors are not aware of research reporting crop injury resulting from the use of a halosulfuron plus *S*-metolachlor tank mixtures or halosulfuron fb *S*-metolachlor in sweetpotato. Given the treatment set used in the present study, it is difficult to tell what, if any, crop injury can be attributed to *S*-metolachlor. Increased stunting injury in the present study is likely due in part to yellow nutsedge interference. Whereas MacRae et al. (2007) and Dittmar et al. (2013) maintained all plots weed free, nutsedge was present throughout the growing season in this study and able to compete with the crop for light, water, and nutrients.

Previous research has documented sweetpotato response to halosulfuron-methyl without consideration of how improved yellow nutsedge control negates a portion of the yield lost to phytotoxic responses. Although halosulfuron-methyl resulted in significant visual, foliar injury to sweetpotato, marketable yields in treated plots were greater than those of the weedy check. In recent years, similar trade-offs between crop injury and increased weed control have been reported for switchgrass (*Panicum virgatum* L.) (Curran et al. 2011) and carrot (*Daucus carota* L.) (Konieczka et al. 2009). Data from the present study suggest that, because of potential crop injury, applications of the described treatments should be applied only to nutsedge-infested areas in sweetpotato fields between 2 and 4 WAP. In such areas, the benefits from improved nutsedge control exceed potential losses associated with crop injury. It should be noted that the present study investigated the response of Beauregard sweetpotato only. Other researchers have reported differential responses for sweetpotato cultivars (Ditmar et al. 2013).

Results from the present study suggest that any of the treatments implemented will increase yellow nutsedge control and sweetpotato yield compared with a weedy check. Given the option, commercial producers would rather make a single application at 2 WAP than two applications. However, at the present time halosulfuron-methyl is not registered for use in sweetpotato, and sweetpotato growers need to rely on delayed *S*-metolachlor applications for chemical control. Current recommendations for weed management in sweetpotato include rotation to more competitive agronomic crops and those with registered and efficacious herbicides for a minimum of 2 yr.

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