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An Evaluation of Pre-emergence Metam-Potassium and *S*-metolachlor for Yellow Nutsedge (*Cyperus esculentus*) Management in Sweetpotato

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Field studies were conducted in 2014 and 2015 at Pontotoc, MS to evaluate combinations of metam-potassium and *S*-metolachlor for yellow nutsedge control and sweetpotato crop response. Treatments consisted of a factorial of five metam-potassium rates (0, 149, 261, 372, and 484 kg ha^{-1}) by three *S*-metolachlor rates (0, 0.80, and 1.34 kg ha^{-1}). Additionally, a hand-weeded check was included for comparison. Crop injury was limited to ≤4% at 4 weeks after transplanting (WAP) and was transient. At 2 WAP yellow nutsedge control was 58, 74, and 76% in plots treated with *S*-metolachlor at 0, 0.80, and 1.34 kg ha^{-1}, respectively. Nutsedge control in all treatments decreased from 2 to 15 WAP. At 15 WAP, *S*-metolachlor at 0, 0.80, and 1.34 kg ha^{-1} provided 35, 68, and 70% yellow nutsedge control, respectively. Metam-potassium rate did not influence yellow nutsedge control after transplanting. Sweetpotato yields in the hand-weeded check were 4,640; 22,180; 7,180; 34,000; and 1,360 kg ha^{-1} for jumbo, no. 1, canner, marketable, and cull grades, respectively. *S*-metolachlor applied at either 0.80 or 1.34 kg ha^{-1} provided jumbo, no. 1, and marketable sweetpotato yields equivalent to the hand-weeded check. Canner and cull yields were not influenced by *S*-metolachlor rate. Metam-potassium rates used in the present study resulted in yields equal to or greater than the hand-weeded check.

Nomenclature: Metam-potassium; *S*-metolachlor; yellow nutsedge, *Cyperus esculentus* L.; sweetpotato, *Ipomoea batatas* L. Lam.

Key words: Crop tolerance, herbicide rate, soil fumigation.

In 2015, Mississippi producers planted 9,390 ha of sweetpotatoes, worth an estimated $80 million of direct value (USDA 2016). Yellow nutsedge is a problematic weed in numerous row crops in the southern United States (Webster and Nichols 2012) including sweetpotato (Webster 2014). Season-long yellow nutsedge interference can reduce marketable sweetpotato yield 6% to 80% at densities of 5 to 90 shoots m^{-2}, respectively (Meyers and Shankle 2015a).

Yellow nutsedge management recommendations for Mississippi sweetpotato producers emphasize tillage that exposes rhizomes and/or tubers to dry conditions or freezing temperatures, removal of nutsedge propagules from equipment prior to leaving an infested field, and rotation to crops that are more competitive with yellow nutsedge and/or have registered herbicides that control nutsedge (Meyers and Shankle 2015b). Even though hand-removing weeds is still very common in sweetpotato production, removal of yellow nutsedge is difficult due to its growth and reproductive characteristics such as low meristematic growth and below-ground propagation.

S-metolachlor is the only herbicide registered for use in sweetpotato that will control or suppress yellow nutsedge. However, *S*-metolachlor use has been associated with reduced sweetpotato yield and root quality when applied immediately after transplanting and followed by a moderate-to-heavy rainfall event (Meyers et al. 2010, 2012; Meyers, Jennings, and Monks 2013; Meyers, Jennings, Monks, and Miller et al. 2013). Research indicates that sweetpotato tolerance to *S*-metolachlor increases when applications are delayed from 0 to 14 d after transplanting (DAP) (Abukari 2014; Meyers et al. 2010; Meyers, Jennings, Monks, and Miller et al. 2013). For this reason, *S*-metolachlor complements sweetpotato weed management systems as a layby application following the final between-row cultivation approximately 2 to 4 wk after transplanting (WAP). However, if a producer waits the recommended

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minimum 14 DAP, there is a risk of yellow nutsedge emergence before *S*-metolachlor application. This is problematic because *S*-metolachlor does not control emerged weeds.

Metam-potassium is used by Mississippi sweetpotato producers to manage soil-dwelling nematodes. Some sweetpotato producers apply metam-potassium for the purpose of controlling nutsedge. Metam-potassium decomposes quickly to methyl isothiocyanate (MITC) and/or hydrogen sulfide (Shaner 2014). Under strongly acidic conditions, metam-potassium can decompose into carbon disulfide and monomethylamine (Shaner 2014). MITC is highly volatile and has herbicidal properties that delay emergence or kill germinating seeds before emergence (Shaner 2014). Because MITC dissipates from the soil within 2 to 3 wk after treatment, in most horticulture crops it is applied immediately prior to applying a plastic film cover. However, in sweetpotato production systems, metam-potassium is applied as a bareground treatment into ridged rows. To the authors' knowledge, reported data pertaining to yellow nutsedge control from metam-potassium applied in this manner is limited at best.

The objectives of this research were to determine the influence of metam-potassium and *S*-metolachlor rates on yellow nutsedge control and sweetpotato tolerance, yield, and quality.

Materials and Methods

Studies were conducted at the Pontotoc Ridge-Flatwoods Branch Experiment Station in Pontotoc, MS in 2014 and 2015. Treatments consisted of a factorial arrangement of five metam-potassium rates (0, 149, 261, 372, and 484 kg ha^{-1}) (K-Pam HL, Amvac Chemical Corp., Los Angeles, CA 90023) by three *S*-metolachlor rates (0, 0.80, and 1.34 kg ha^{-1}) (Dual Magnum, Syngenta Crop Protection, LLC, Greensboro, NC 27419). A hand-weeded check was included for comparison. Metam-potassium treatments were applied in an 18-cm band 25 cm deep with a small plot fumigation application rig on May 16, 2014 and May 22, 2015. *S*-metolachlor treatments were applied with a tractor-mounted CO_2-pressurized sprayer calibrated to deliver 140 L ha^{-1} at 160 kPa and fitted with 8002 XR nozzle tips (Teejet 8002 XR, Teejet Technologies, Springfield, IL). The experimental design was split-plot with four replications. Main plots consisted of metam-potassium rate. Subplots of *S*-metolachlor rate were randomly placed within each main plot.

All plots received 109 g ai ha^{-1} flumioxazin (Valor® SX, Valent USA Corp., Walnut Creek, CA) before transplanting to control broadleaf weeds endemic to the field. 'Beauregard' sweetpotato slips approximately 30 cm long were mechanically transplanted 30 cm apart into ridged rows on June 6, 2014 and June 19, 2015 into a Falkner silt loam (fine-silty, siliceous, thermic Aquic Paleudalf) with pH 6.9 and 1.3% organic matter. Plot size was four rows, each 9 m long. All four rows were treated, but data were only collected for the center two rows of each plot. Yellow nutsedge was the predominant weed in fields utilized for this study. Additional weed species were hand-removed weekly. All plots were cultivated between rows with a rolling cultivator 3 to 4 WAP and received a single application of 136 g ai ha^{-1} clethodim (Select Max, Valent USA Corp., Walnut Creek, CA 94596), plus nonionic surfactant at 0.25% (v/v), to control emerged annual and perennial grass species.

Foliar sweetpotato injury and yellow nutsedge control were visually evaluated 2, 4, 6, 8, 10, and 15 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 center two rows of each plot 110 and 109 DAP in 2014 and 2015, respectively, using a single-row tractor-mounted chain digger. Storage roots were hand-graded into jumbo (≥8.9 cm in diameter), no. 1 (≥4.4 cm but <8.9 cm), canner (≥2.5 cm but <4.4 cm), and cull (misshapen roots) (USDA 2005) and weighed. 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® version 9.3, SAS Institute Inc., Cary, NC) Proc Mixed with the fixed effects of metam-potassium rate and *S*-metolachlor rate and the random effects of year and replication within year. When ANOVA indicated a significant treatment effect, means were separated by Fisher's Protected LSD ($P \leq 0.05$). Visual sweetpotato injury and yellow nutsedge control ratings were arcsin-squareroot transformed for analysis and are presented as untransformed data for discussion purposes. The hand-weeded check was included in yield analysis. However, crop injury and yellow nutsedge control data from the check were not included in data analysis due to zero variance.

Results and Discussion

Due to a lack of treatment by year interaction, data for visual crop injury, yellow nutsedge control, and sweetpotato yield were analyzed across both 2014 and 2015. Due to a lack of metam-potassium rate by *S*-metolachlor rate interaction, the main effect of metam-potassium rate was analyzed across all rates of *S*-metolachlor and the main effect of *S*-metolachlor rate was analyzed across all rates of metam-potassium.

Sweetpotato Injury. Limited sweetpotato stunting injury was observed (data not shown) and it did not correlate with either metam-potassium or *S*-metolachlor rates. Injury was limited to ≤4% at 4 WAP, was transient, and was 0% for all treatments by 8 WAP.

Yellow Nutsedge Control. Immediately prior to transplanting, yellow nutsedge control increased from 0% to 73% as metam-potassium rate increased from 0 to 484 kg ha^{-1} (Table 1). However, after sweetpotatoes were transplanted, there was no additional effect of metam-potassium on yellow nutsedge control. Nutsedge control with metam-containing products has been historically inconsistent. Gilreath et al. (2005) reported reduced nutsedge densities in one of three growing seasons when metam-sodium was drip-applied at 710 L ha^{-1} in bell pepper (*Capsicum annuum* L.) grown on black polyethylene film. Locascio et al. (1997) reported that soil-injected or drip-applied metam-sodium at 300 L ha^{-1} did not improve nutsedge control compared to a non-treated check in polyethylene-mulched tomato (*Solanum lycopersicum* L.). Klose et al. (2008) exposed yellow nutsedge tubers to concentrations of metam-sodium from 10 to 2,650 µmol kg^{-1} soil and reported that "logistic models did not adequately describe the relationship between all metam-Na concentrations and the mortality of *C. esculentus*".

S-metolachlor rate influenced yellow nutsedge control throughout the duration of the study (Table 2). At 2 WAP, yellow nutsedge control was 58%, 74%, and 76% in plots treated with 0, 0.80, and 1.34 kg ha^{-1} *S*-metolachlor, respectively. Nutsedge control in all treatments decreased from 2 to 15 WAP. At 15 WAP, *S*-metolachlor at 0, 0.80, and 1.34 kg ha^{-1} provided 35%, 68%, and 70% yellow nutsedge control, respectively. Throughout the season, yellow nutsedge control with 0.80 and 1.34 kg ha^{-1} *S*-metolachlor was equivalent, which suggests rates higher that 0.80 kg ha^{-1} will not improve control. This trend was similar to that observed by Meyers et al. (2010) who reported that season-long Palmer amaranth control in sweetpotato was similar among *S*-metochlor rates of 0.8, 1.1, and 1.3 kg ha^{-1}.

Sweetpotato Yield. *Effect of Metam-Potassium Rate.* Sweetpotato yields in the hand-weeded check were 4,640; 22,180; 7,180; 34,000; and 1,360 kg ha^{-1} for jumbo, no. 1, canner, marketable, and cull grades, respectively (Table 1). With the exception of metam-potassium at 149 kg ha^{-1}, which had lower no. 1 and marketable yields than did the hand-weeded check, metam-potassium rates used in the present study resulted in yields equal to or greater than the hand-weeded check.

Effect of S-metolachlor Rate. Sweetpotato yield data followed the same trend as did yellow nutsedge control.

Table 1. Effect of metam-potassium rate on yellow nutsedge control and sweetpotato yield at Pontotoc, MS across 2014 and 2015.

Treatment	CYPES[a]	Sweetpotato yield				
Metam-potassium rate	0 WAP	Jumbo	No. 1	Canner	Marketable[b]	Cull
kg ha^{-1}	%	kg ha^{-1}				
Hand-weeded check	–	4,640	22,180	7,180	34,000	1,360
0	0	4,030	19,530	6,890	30,450	1,750
149	31	3,580	17,610	8,080	29,270	1,300
261	55	4,330	19,860	8,180	32,370	1,340
372	71	3,570	21,990	7,640	33,200	1,080
484	73	3,720	19,940	7,610	31,270	1,180
LSD ($P \leq 0.05$)	3	NS	3,180	930	3,640	470

[a] Abbreviations: CYPES = yellow nutsedge; NS = not significant; WAP = wk after transplanting.

[b] Marketable is the aggregate of jumbo, no. 1, and canner grades.

Table 2. Effect of *S*-metolachlor rate on yellow nutsedge control and sweetpotato yield at Pontotoc, MS averaged across 2014 and 2015.

Treatment	CYPES[a] control (WAP)					Sweetpotato yield				
S-metolachlor rate	2	4	6	8	15	Jumbo	No. 1	Canner	Marketable[b]	Cull
kg ha^{-1}	%					kg ha^{-1}				
Hand-weeded check	–	–	–	–	–	4,640	22,180	7,180	34,000	1,360
0	58	47	42	37	35	2,800	18,330	7,990	29,120	1,100
0.80	74	75	72	71	68	4,170	20,180	7,720	32,070	1,430
1.34	76	78	75	74	70	4,590	20,970	7,350	32,910	1,450
LSD ($P \leq 0.05$)	11	10	10	11	11	1,180	3,000	NS	3,440	NS

[a] Abbreviations: CYPES = yellow nutsedge; NS not significant; WAP = wk after transplanting.

[b] Marketable is the aggregate of jumbo, no. 1, and canner grades.

S-metolachlor applied at either 0.80 or 1.34 kg ha^{-1} provided jumbo, no. 1, and marketable sweetpotato yields equivalent to those of the hand-weeded check. Canner and cull yields were not influenced by *S*-metolachlor rate.

Soil-injected metam-potassium does not appear to be beneficial for yellow nutsedge management in the current Mississippi sweetpotato production system; however, its use did not reduce sweetpotato yield in the present study. Alternative application methods for metam-potassium in sweetpotato may be useful. For example, Johnson and Mullinix (2007) reported that 747 L ha^{-1} of nondiluted metam-sodium sprayed in a 61-cm band and incorporated with a rototiller to a depth of 7.6 cm provided 75% control of yellow nutsedge in bare-ground grown cantaloupe (*Cucumis melo* L.). Gilreath et al. (1994) reported greater nutsedge control with surface-applied metam-sodium rototilled to a depth of 15 to 20 cm than with soil injected metam-sodium in polyethylene mulched tomato.

Results from the present study suggest that *S*-metolachlor is beneficial in a yellow nutsedge weed management program and that the benefits of applying *S*-metolachlor PRE to sweetpotato fields with a history of yellow nutsedge infestation outweighs the potential risks of yield loss due to a phytotoxic response. Given that no other herbicide registered for use in sweetpotato offers equivalent control of yellow nutsedge and that nutsedge densities that typically occur in sweetpotato production fields can result in significant yield losses (Meyers and Shankle 2015a), *S*-metolachlor should be considered for application immediately after transplanting only in fields with a history of nutsedge infestation. However, because *S*-metolachlor requires an activating rainfall or irrigation event prior to yellow nutsedge emergence, a system that relies solely on *S*-metolachlor for yellow nutsedge control is not encouraged. Other management options include the utilization of integrated pest management practices such as rotating to crops that are more competitive with yellow nutsedge and/or have herbicides that are efficacious for nutsedge, and removing yellow nutsedge propagules from equipment before entering a non-infested field. For all other weed species controlled by other registered herbicides, *S*-metolachlor should still be delayed until at least 14 DAP to limit potential crop injury and yield losses.

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