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SUGARCANE RESPONSE TO GLYPHOSATE RIPENER WHEN MIXED WITH 2,4-D OR ATRAZINE

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ABSTRACT

Management of late-season morningglory infestations in sugarcane is accomplished with aerial applications of the postemergence herbicides 2,4-D, dicamba, or atrazine. Likewise, the aerial application of glyphosate prior to harvest to improve stalk sucrose levels is a common practice for many Louisiana producers. The tank-mixing of glyphosate ripener and 2,4-D, dicamba, or atrazine has been avoided by most producers because research has shown cases of antagonism or a reduction in weed control efficacy when glyphosate is tank-mixed with 2,4-D amine formulation, 2,4-D ester formulation, bromoxynil, dicamba, or atrazine. Research conducted in 2016 at two locations showed that the tank-mixing of glyphosate (210 g acid equivalent (ae) ha^{-1}) + 2,4-D (530 g ae ha^{-1}) or glyphosate (210 g ae ha^{-1}) + atrazine (3360 g ai (active ingredient (ai) ha^{-1}) did not reduce ripener efficacy when compared to glyphosate (210 g ae ha^{-1}) alone. The tank-mixing of these products also provides a means for controlling late-season morningglory infestations, which improves harvester efficiency and reduces aerial applicator costs.

Keywords: Sugarcane ripener, glyphosate, 2,4-D, atrazine, morningglory control.

INTRODUCTION

Common species of morningglories found in Louisiana sugarcane (*Saccharum* spp.) fields include red morningglory (*Ipomoea coccinea*), ivyleaf morningglory [*Ipomoea hederacea*

(L.) Jacq.], entireleaf morningglory (*Ipomoea hederacea* var. *integriuscula* Gray), pitted morningglory (*Ipomoea lacunosa* L.), smallflower morningglory [*Jacquemontia tamnifolia* (L.) Griseb.], and cypressvine morningglory (*Ipomoea quamoclit* L.) (Jones and Griffin 2008; Millhollon 1988). Several pre- and postemergence herbicide options are available to manage early-season morningglories beginning in spring through layby (May/June). Preemergence herbicides are often rapidly degraded after layby due to excessive rainfall events and high soil temperatures in Louisiana, leading to late-season morningglory infestations (Viator et al. 2002b). Morningglories wrap around and climb up the cane stalks, thus reducing sunlight penetration into the crop's canopy, and ultimately reducing the number of millable stalks and sugar yield (Millhollon 1988). Severe infestations of morningglories can completely collapse the sugarcane plant and reduce sugar yield 24 to 30% (Millhollon 1988). Late-season morningglories in Louisiana are controlled with aerial applications of the postemergence herbicides 2,4-D [(2,4-dichlorophenoxy) acetic acid], dicamba [3,6-dichloro-2-methoxybenzoic acid], or atrazine [6-chloro-N-ethyl-N-(1-methylethyl) -1,3,5-triazine-2,4-diamine]. If not controlled prior to harvest, morningglories wrap around the combine harvester's crop dividers, basecutter, knockdown roller, and feed rollers, leading to clogs and reduced harvester efficiency.

In Louisiana, the harvesting of sugarcane (*Saccharum* spp.) typically begins in late-September and concludes in early-January. At the beginning of the harvest season, sugarcane maturity, in terms of sucrose concentration (g sucrose kg^{-1} sugarcane) is lowest and subsequently increases throughout the harvest season. In 1980, glyphosate [N-(phosphonomethyl) glycine] was labeled as a sugarcane ripener (Legendre and Finger 1987) and is currently used by many Louisiana sugarcane producers to improve early season sucrose concentration. Glyphosate (210 g ae ha^{-1}) is typically applied by aircraft or high-crop ground machines in Louisiana beginning in mid-August and applications continue through mid-October (Legendre et al. 2015). The recommended treatment-to-harvest interval for treated sugarcane ranges from 28 to 35 days for sugarcane harvested from September 15 to October 15, 28 to 49 days for sugarcane harvested from October 15 to November 15, and 35 to 49 days for sugarcane harvested from November 15 to December 1 (Legendre et al. 2015).

The tank-mixing of multiple herbicides is common for many row crop producers, which allows for fewer passes throughout the growing season, ultimately reducing production costs. However, the tank-mixing of certain herbicides reduced the efficacy of one or both products. Studies by O'Donovan and O'Sullivan (1992) showed that absorption and translocation of ^{14}C-glyphosate was reduced when mixed with 2,4-D amine, 2,4-D ester, or bromoxynil in barley (*Hordeum vulgare*); however if the products were applied at the same concentrations to different sites on the same leaf, ^{14}C-glyphosate absorption and translocation was not affected. In a similar study, Flint and Barrett (1989) showed an increase in johnsongrass (*Sorghum halepense*) shoot weight when 2,4-D or dicamba was mixed with glyphosate, 4 weeks after treatment, suggesting a reduction in glyphosate uptake. Quackgrass [*Agropyron repens* (L.) Beauv.] and common dandelion (*Taraxacum officinale* Weber) control was reduced by 41 and 44%, respectively, 28 days after treatment when glyphosate was mixed with atrazine, as compared to glyphosate alone (Selleck and Baird 1981).

The objective of this study was to determine if 2,4-D or atrazine mixed with glyphosate reduces ripener efficacy.

MATERIALS AND METHODS

Field experiments were conducted at LSU AgCenter's Sugar Research Station in St. Gabriel, LA, and at the USDA-ARS Sugarcane Research Unit's Ardoyne Farm in Schriever, LA on first ratoon 'HoCP 96-540'. The soil type at each location was classified as a Commerce silt loam (Fine-silty, mixed, nonacid, thermic Aeric Fluvaquent). Plot size was 1.8 m (1 row) by 12.2 m with a 1.5 m untreated buffer between plots. The experimental design was a randomized complete block, and treatments were replicated three times.

Ripener treatments included, glyphosate (210 g ae ha^{-1}) (Roundup PowerMAX® II, Monsanto Company, 800 N. Lindbergh Blvd., St. Louis, Mo 63167), glyphosate (210 g ae ha^{-1}) + 2,4-D (530 g ae ha^{-1}) (Weedar® 64, Nufarm Inc., 11901 S. Austin Avenue, Alsip, IL 60803) formulated as a dimethylamine salt, glyphosate (210 g ae ha^{-1}) + atrazine (3360 g ai ha^{-1}) (Aatrex®, Syngenta Crop Protection, Inc., P.O. Box 18300, Greensboro, NC 27419), and a nontreated control. Treatments were applied at both locations on August 31, 2016 using a pressurized CO_2 backpack sprayer calibrated to deliver 140 L ha^{-1} using XR 11002 flat fan nozzles (TeeJet, 1801 Business Park Drive, Springfield, IL 62703) set at 193 kPa. No additional surfactant was added to the herbicide treatments.

A visual estimate of morningglory control was made 28 days after treatment application (DAT). Control was compared with the nontreated using a scale of 0 to 100%, where 0 represented no control, and 100 equaled complete control.

A 10-stalk sample from each plot was hand-harvested on September 28, 2016, 28 DAT. Stalks were topped at the growing point and stripped of leaves and weighed for an estimate of stalk weight (kg). Samples were crushed using a three-roller mill and juice was analyzed for Brix and pol using a refractometer and saccharimeter, respectively. Sucrose content (g kg^{-1}) was calculated from these analyses using standard methodologies (Chen and Chou, 1993). Plots were harvested with a sugarcane chopper harvester, and the harvested sugarcane was loaded into a wagon equipped with load cells, and the weight of each plot was recorded. The sum of the plot weights and sample weights was used to calculate sugarcane yield (Mg ha^{-1}). Sugar yield (kg ha^{-1}) was calculated as the product of sucrose content (g kg^{-1}) and cane yield (Mg ha^{-1}).

Data were analyzed using SAS v9.4 software (SAS Institute 2012) and were subjected to the Proc Mixed procedure using the following linear model.

$$Y_{ijk}=\mu+L_i+R_{j(i)}+T_k+ TL_{ik} + E_{ijk}.$$

Y_{ijk} is the observed response in location i in replication j(i) of ripener treatment k. μ is the overall mean; L_i is the location effect; $R_{j(i)}$ is the replication effect nested within location; T_k is the ripener treatment effect; TL_{jk} is the interaction of treatment with location; E_{ijk} is the experimental error. Location and replication were considered random effects, and ripener treatment was considered a fixed effect. Least square means were estimated and tested for statistical significance (P=0.05) with the Student's t test using the PDIFF option of PROC MIXED. Letter groupings were converted using the PDMIX800 macro (Saxton 1998).

RESULTS AND DISCUSSION

There was a significant ($P \leq 0.05$) treatment effect for sucrose concentration (g kg^{-1}) (Table 1). At harvest, the tank-mix treatments of glyphosate + 2,4-D and glyphosate + atrazine had a similar sucrose concentration to the glyphosate alone treatment, which averaged 11.8 to 13.5% above the nontreated check, 28 DAT (Table 2). In two other experiments, Orgeron et al. (2013; 2015) reported an 11.1 and 13.0% increase in sucrose concentration for HoCP 96-540 when treated with glyphosate 210 g ae ha^{-1}, 28 DAT. Other researchers investigating glyphosate as a ripener have shown consistent increases in stalk sucrose concentration for many sugarcane cultivars (Andrels and DeStefano 1980; Clowes 1980; Martin et al. 1981; Millhollon and Legendre 1996; Tianco and Gonzales 1980).

Morningglory plants were distributed consistently throughout the experiment conducted at the Sugar Research Station, however this was not the case for the USDA-ARS Sugarcane Research Unit experiment, thus morningglory control was not evaluated. Glyphosate provided 0% morningglory control; however glyphosate treatments with 2,4-D and atrazine provided 100% control of morningglory, 28 DAT. It was noted that the morningglory plants desiccated more quickly for the glyphosate + 2,4-D treatment than the glyphosate + atrazine treatment (data not reported). This is consistent with previous reports by Siebert et al. (2004) which showed, control of 1.8 m red morningglory was greater for 2,4-D as compared to atrazine at 7 and 14 DAT, but complete control was obtained for both products 28 DAT.

These findings demonstrate that the ability of glyphosate to ripen immature sugarcane was not compromised when 2,4-D or atrazine herbicides were tank-mixed with it. The combination of glyphosate with 2,4-D or atrazine will control late-season morningglory infestations and increase stalk sucrose concentration. This practice will ultimately improve sucrose yield and harvester efficiency, and reduce aerial applicator cost.

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Table 1. Analysis of variance of fixed effect for the 2016 first ratoon crop of HoCP 96-540 for experiments conducted at the Sugar Research Station in St. Gabriel, LA and USDA-ARS Sugarcane Research Unit in Schriever, LA.

Source of variance	Mean Stalk Wt. (kg)	Sucrose concentration (g kg^{-1})	Sugarcane yield (Mg ha^{-1})	Sucrose yield (kg ha^{-1})
	--------------------	P-value	--------------------	
Treatment	0.5997	<0.0001	0.2432	0.1310

Table 2. 'HoCP 96-540' first ratoon treatment means averaged across experiments conducted at the Sugar Research Station in St. Gabriel, LA and USDA-ARS Sugarcane Research Unit in Schriever, LA.

Treatment	Mean Stalk Wt. (kg)	Sucrose concentration (g kg^{-1})	Sugarcane yield (Mg ha^{-1})	Sucrose yield (kg ha^{-1})
Nontreated	0.59 a[2]	118 b	67.6 a	8070 a
Glyphosate[1]	0.64 a	134 a	64.8 a	8832 a
Glyphosate + 2,4-D	0.61 a	134 a	60.7 a	8224 a
Glyphosate + Atrazine	0.64 a	132 a	64.7 a	8644 a

[1]Treatments were applied on 8-31-2016 using a pressurized CO_2 backpack sprayer calibrated to deliver 140 L ha^{-1} using XR 11002 flat fan nozzles (TeeJet, 1801 Business Park Drive, Springfield, IL 62703) set at 193 kPa. Glyphosate @ 210 g ae ha^{-1}, 2,4-D @ 530 g ae ha^{-1}, and atrazine @ 3360 g ai ha^{-1}.

[2]Means within a column followed by the same lowercase letter are not significantly different.