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WEED SCIENCE

Glyphosate-Resistant Soybean Interference in Glyphosate-Resistant Cotton

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ABSTRACT

A negative aspect of glyphosate-based management systems is the potential for volunteer glyphosate-resistant (GR) crop plants to impact subsequent crops. Studies were conducted to evaluate density and duration of interference effects of GR soybean (*Glycine max* (L.) Merr.) on GR cotton (*Gossypium hirsutum* L.) growth and yield. Our study demonstrated that regardless of soybean density and duration of interference, soybean did not affect cotton height at harvest. Season-long interference with a soybean density of 1 plant per row m would be expected to reduce cotton yield 14%. A cotton yield reduction of 0.4 to 1% can be expected with only 1 week of soybean interference at a density of 5.25 plants per row m. Expected yield reductions of 1 to 3, 5 to 6, and 8 to 11% would be observed with soybean interference for 2, 4, and 6 weeks, respectively. Results demonstrate the sensitivity of cotton yield to soybean interference, indicating that soybean can be considered a problematic weed in cotton necessitating early management.

INTRODUCTION

Commercialization of glyphosate-resistant (GR) technology in cotton provided producers a highly efficacious and cost effective weed management option. These systems require fewer herbicide applications, thereby allowing greater weed management flexibility when compared to conventional weed management programs (Clewis and Wilcut, 2007; Culpepper and York, 1999). In addition, glyphosate-based management systems in cotton allow producers to integrate weed, insect, and crop management strategies through chemical co-application of glyphosate with insecticides, micronutrients, and plant growth regulators (Scroggs et al., 2005; Miller et al., 2008). Due in part to these positive attributes, GR cotton has been widely accepted by growers, with 74% of the crop in the United States planted to GR cultivars less than a decade after commercialization (Sankula and Blumenthal, 2004).

One negative aspect of glyphosate-based management systems in GR cultivars is the potential for volunteer GR crop plants in subsequent crops, thereby requiring additional management inputs (York et al., 2004, 2005). Volunteers of one crop can directly interfere with growth and yield of the rotational crop and potentially interfere with harvest. In the Great Plains, volunteer wheat (*Triticum aestivum* L.) was reported as becoming more common and gaining greater profile as a weed (Harker et al., 2005). Thomas et al. (2007) indicated GR corn (*Zea mays* L.) at a density of 5.25 plants per m GR cotton row reduced late-season cotton height 24 to 49%. One corn plant per m of crop row decreased cotton lint yield 5 to 8%. In a 1-year study, Tingle and Beach (2003) reported GR cotton at a density of 1 plant per row m reduced GR soybean yield 6%, while a GR soybean density of 0.5 and 1 plant per row m reduced cotton yield at least 7%.

Limited research has been conducted on the impact of interference of GR soybean in GR cotton. Therefore, this research was conducted to determine the effect of soybean density and duration of interference in cotton.

MATERIALS AND METHODS

Field experiments were conducted at the Northeast Research Station near St. Joseph, LA, the Peanut Belt Research Station near Lewiston, NC, the Upper Coastal Plains Research Station near Rocky Mount, NC, and the Central Crops Research Station near Clayton, NC in 2004 and 2005. The

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experimental design was a randomized complete block with treatments replicated four times at St. Joseph and 3 or 4 times at Clayton, Rocky Mount, and Lewiston. To ensure weed-free conditions throughout the season, glyphosate (Roundup Weathermax, Monsanto, St. Louis, MO) at 916 g a.e. ha^{-1} was applied using a hooded sprayer in row middles and post directed spray nozzles angled toward the crop row approximately 2, 4, and 6 wk after planting. Plots consisted of two rows 12 m long in Louisiana and 6 m long in North Carolina with a row spacing of 102 cm at both locations. Cotton (13 seed m^{-1} row) and soybean were planted at St. Joseph on 26 May 2004 and 18 May 2005, at Rocky Mount on 11 May 2004 and 27 April 2005, at Lewiston on 13 May 2004, and at Clayton on 6 May 2004 and 29 April 2005. Soil types were a Mhoon silt loam (fine-silty, mixed nonacid, thermic Typic Fluvaquent) at St. Joseph, a Norfolk loamy sand (fine-loam, siliceous, thermic Typic Kandiudults) at Lewiston and Rocky Mount, and a Goldsboro sandy loam (fine-loamy, siliceous, thermic Aquic Paleudalts) at Clayton. Conventional soil tillage practices including disking and row formation in spring were utilized.

Density Study. In the density study, experiments were conducted both years in Louisiana and at all three North Carolina locations in 2004. In Louisiana, soybean 'DP 5644RR' was planted approximately 5 cm beside 'PM 1218RR' cotton rows and in North Carolina, 'Asgrow 6202RR' was planted approximately 5 cm beside 'FM 989RR' cotton rows. After emergence, soybean was thinned to densities of 0, 0.16, 0.33, 0.66, 1.3, 2.6, or 5.25 plants per m of row and allowed to compete season-long.

Duration of Interference. Cultivars for this study were the same used in the density study. Experiments were conducted both years at St. Joseph, Louisiana and at Clayton, North Carolina and in 2005 at Rocky Mount, North Carolina. Soybean was planted approximately 5 cm beside the cotton rows and thinned after emergence to a density of 5.25 plants per m of row. GR soybean was allowed to compete with the cotton crop from emergence for 1, 2, 3, 4, 5, 6, 7, or 8 wk and season-long in Louisiana and 1, 2, 4, 6, 8, 10, or 12 wk and season-long in North Carolina. The soybean plants were removed by hand at each interference interval by cutting at the soil line.

Data Collection and Statistical Analysis. In both studies, cotton height was determined prior to harvest from 10 randomly selected plants from the ground to the plant terminal. Cotton was mechanically harvested from the entire plot and seedcotton yield was determined. The MIXED procedure analysis was performed on cotton height and yield data using SAS (2003). For the density study, location was considered a random variable. For the duration of the interference study, due to differing duration intervals, Louisiana and North Carolina locations were analyzed separately. Within each location, however, experiment was considered a random variable. If significant effects for density or duration of interference were found, then post-ANOVA polynomial response effects were explored. Expected percentage reductions alluded to in subsequent discussion were calculated using the polynomial regression factors associated with the particular variable of interest (intercept value – calculated expected value/intercept value * 100).

RESULTS AND DISCUSSION

Density study. A significant soybean density effect was not observed with respect to cotton height, which ranged from 102 to 123 cm (Table 1). There was, however, a significant soybean density effect on cotton yield. Based on polynomial regression factors, a cotton yield reduction of approximately 35% can be expected with a soybean density of 3 plants per row m (Table 1). A soybean density of 0.5 and 1 plant per row m would be expected to reduce yield 7 and 14%, respectively. In previous research, a similar density of 1 GR corn plant per row m reduced GR cotton yield 5 to 8% (Thomas et al., 2007). Cotton lint yield loss from broadleaf weeds including Palmer amaranth (*Amaranthus palmeri* S. Wats), ivyleaf morningglory (*Ipomoea hederacea* Jacq.), jimsonweed (*Datura stramonium* L.), ladysthumb (*Polygonum persicaria var.* persicaria L.), Pennsylvania smartweed (*Polygonum pensyvanicum* var. *laevigatum* Fern.), pale smartweed (*Polygonum lapathifolium* L.), tropic croton (*Croton glandulosus* var. *septentrionalis* Muell.-Arg.), and velvetleaf (*Abutilon theophrasti* Medicus), ranged from 22 to 69% at a density of 1 plant per row m (Askew and Wilcut, 2001, 2002a, 2002b, 2002c; Bailey et al., 2003; Morgan et al., 2001; Rogers et al., 1996; Rowland et al., 1999; Scott et al., 2000, Wood et al., 1999). Tingle and Beach (2003) reported at least a 7% GR cotton yield reduction with GR soybean interference at 0.5 or 1 plant per row m.

Table 1. Observed values and corresponding regression equation describing relationship between season-long glyphosate-resistant soybean interference at varying densities and mature cotton height and yield.[y]

Density	Cotton height[z]	Seedcotton yield
Plants per row m	cm	kg/ha
0	109	2147
0.16	105	2062
0.33	104	1967
0.66	105	1873
1.3	102	1686
2.6	107	1509
5.25	123	1195
Regression equation:	NS	$Y = 2125.31 - 318.12 (D) + 28.15 (D)^2$

[y] Experiments conducted in 2004 and 2005 at St. Joseph, La and at Lewiston, Rocky Mount, and Clayton, NC in 2004. Experiment/year considered a random effect in PROC MIXED data analysis.

[z] Significant density effect not observed on cotton height at maturity.

Duration of interference study. Duration of cotton interference did not affect cotton height at Louisiana (115 to 121 cm) (Table 2) or North Carolina (86 to 93 cm) (Table 3). There was, however, a significant soybean duration of interference effect on cotton yield. At Louisiana, a cotton yield reduction of 1% can be expected with only 1 week of soybean interference at a density of 5.25 plants per row m (Table 2). Expected yield reduction of 3, 6, and 8% would be observed with soybean interference for 2, 4, and 6 wks, respectively. At North Carolina, cotton yield reduction of 0.4, 1, 5, and 11% would be expected for soybean interference intervals of 1, 2, 4, and 6 weeks, respectively (Table 3). In contrast, Tingle and Beach (2003) reported that GR soybean at a density of 1 plant per row m had to compete with GR cotton at least 8 week after planting before yield loss was observed. Ivyleaf morningglory densities of 20 to 35 plants per m^2 reduced cotton yield 7.8 and 11.2% for each week of interference up to 11 and 9.5 weeks, respectively (Rogers et al., 1996).

Table 2. Observed values and corresponding regression equation describing relationship between glyphosate-resistant soybean interference at varying duration intervals and mature cotton height and yield.[y]

Interference interval	Cotton height[z]	Seedcotton yield
weeks	cm	kg/ha
0	119	2628
1	117	2441
2	121	2573
3	121	2484
4	115	2536
5	115	2472
6	119	2536
7	115	2375
8	116	1956
20	112	1235
Regression equation:	NS	$Y = 2608.49 – 29.06 (wk) – 2.0215 (wk)^2$

[y] Experiment conducted in 2004 and 2005 at St. Joseph, La. Year considered a random effect in PROC mixed data analysis.

[z] Significant duration of interference effect not observed on cotton height at harvest.

Table 3. Observed values and corresponding regression equation describing relationship between glyphosate-resistant soybean interference at varying duration intervals and mature cotton height and yield.[y]

Interference interval	Cotton height[z]	Seedcotton yield
weeks	cm	kg/ha
0	93	998
1	87	950
2	93	957
4	90	920
6	91	921
8	86	795
10	92	790
12	88	589
22	86	433
Regression equation:	NS	$Y = 983.89 - 3.74\ (wk)^2 + 0.12\ (wk)^3$

[y] Experiments conducted at Clayton, NC in 2004 and 2005 and at Rocky Mount, NC in 2005. Experiment/wear considered a random effect in PROC mixed data analysis.

[z] Significant duration of interference effect not observed on cotton height at harvest.

Our results indicate that GR soybean seed germinating and emerging as volunteers in a subsequent GR cotton crop have the potential to be very competitive as weeds. It should be noted that other critical factors, including impacts on harvest efficiency and insect/disease host potential were not taken into account with the current research and should be considered when implementing control strategies. In this research, soybean emerged simultaneously with cotton and negative effects on growth and yield may be more pronounced if soybean becomes well established prior to cotton emergence. Tingle and Beach (2003) reported that GR soybean at a density of 1 plant per row m reduced GR cotton yield 7% when emerging simultaneously. When soybean was introduced 2 wk prior to cotton planting, however, yield was reduced 38%. Therefore, producers are cautioned that volunteer soybean plants should be removed prior to cotton planting if at all possible.

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