INFLUENCE OF HERBICIDE SYSTEM ON SPIDER MITES IN GEORGIA COTTON

R.J. Brannen
P.M. Roberts
A.S. Culpepper
University of Georgia
Tifton, GA

Abstract

Field experiments were conducted to determine the effect of glufosinate and glyphosate-based herbicide systems on spider mite infestations in Georgia cotton. The experiments also compared the efficacy of glufosinate applied as a miticide with the miticides abamectin, spiromesifen, and aldicarb. Early-season POST herbicide applications of glufosinate reduced spider mite populations for approximately 30 days following treatment when compared with early season POST herbicide applications of glyphosate. However, when glufosinate was applied as a miticide during mid-season, it did not control spider mites as consistently as the miticides spiromesifen and abamectin. Results demonstrated that spider mites can be an economic pest of cotton in Georgia. A significantly higher yield was observed in the dryland trial where foliar applications of spiromesifen were applied during mid-season. In the irrigated trial, significantly (P=0.1) higher yields were also observed where abamectin was applied during mid-season for control of spider mites.

Introduction

Spider mites can cause damage and yield loss in a cotton crop (Reddall et al, 2004; Wilson, 1993). While not a consistent pest of cotton in Georgia, two spotted spider mites have the potential to reach damaging levels, especially in hot, dry conditions (Steinkraus et al). Also, applications of insecticides such as acephate can result in increased populations of spider mites by destroying their natural enemies (Bartlett, 1968). Cotton varieties with resistance to topical glufosinate applications are commercialized and becoming more popular. In addition to providing another option for weed control, the herbicide glufosinate has been shown to have efficacy against spider mites (Ahn et al, 1997). Insecticides such as acephate are commonly applied to control early season thrips and can flare spider mites (Bartlett, 1968). Herbicides, either glyphosate or glufosinate, are applied over-the-top of cotton during this same period of time. Because glufosinate offers some level of control of spider mites, the use of a glufosinate-based herbicide system could offer farmers some protection against spider mite populations that could be flared by broad spectrum insecticide applications made to control thrips and other pests. The objective of this research was to determine if the utilization of a glufosinate-based herbicide system could reduce the risk of spider mite infestations compared with a glyphosate-based system.

Materials and Methods

Two field experiments were established during 2010 in Tift County, GA, using a split-plot design with four replications. Main plots were 16 rows wide and 40 feet in length and sub-plots were four rows wide and 40 feet in length. The two main treatments included a glyphosate-based herbicide system or a glufosinate-based herbicide system. In the glyphosate-based herbicide system, any early-season POST herbicide applications consisted of glyphosate (1.0 lb ae/a), and in the glufosinate-based herbicide system, any early-season POST herbicide applications consisted of glufosinate (0.53 lbs ai/acre). The sub-plots included selected miticide treatments. The miticide treatments in Trial 1 were abamectin (0.009 lbs ai/acre), glufosinate (0.53 lbs ai/acre), and an untreated control. The miticide treatments for Trial 2 were spiromesifen (0.125 lbs ai/acre), glufosinate (0.53 lbs ai/acre), aldicarb (0.75 lb ai/acre) applied in-furrow at planting, and an untreated control. Trial 1 was irrigated and utilized a conventional tillage system. Trial 2 was dryland and utilized a conservation tillage system. Both trials were planted in PHY 375 WRF. This glyphosate-resistant cotton also contains a gene, used as a selectable marker, for glufosinate resistance (Culpepper et al, 2009). The glufosinate resistance gene is inserted into Widestrike cotton for use as a selectable marker during plant transformation to incorporate the *Bt* genes that confer resistance to lepidopteran pests. While this gene confers a level of tolerance to glufosinate in Phytogen cotton varieties designated as Widestrike, including PHY 375 WRF, the tolerance is not complete. If glufosinate is applied topically to these varieties, crop injury will occur. After each application of glufosinate, either as a herbicide applied early-season POST or as a miticide applied topically mid-season, glufosinate injury was visibly estimated on a scale of 0 (no crop injury) to 100 percent (crop death) approximately 1 week after application (Frans et al, 1986).

Trial 1 was planted on April 28. Pendimethalin (0.95 lb ai/a) was applied PRE immediately after planting to the trial area and a half inch of irrigation was applied within 24 hours to activate the herbicide and enhance seedling germination. The trial area was cultivated on May 7, 2010 to control weeds in the middles. One POST herbicide application was applied banded over the row at the 5 leaf-stage on May 24. A lay-by application of diuron (1.0 lb ai/acre) and glyphosate (1.0 lb ae/a) was applied to the entire trial area with directed-spray nozzles on June 17.

Trial 2 was planted on May 19 and glyphosate (1.0 lb ae/a) was applied PRE after planting to the trial area for initial weed control. Two POST herbicide applications were applied broadcast, the first at the 2-leaf stage on June 4 and the second at the 7-leaf stage on June 17. As in Trial 1, a lay-by application of diuron (1 lb ai/acre) and glyphosate (1.0 lb ae/a) was applied to the entire trial area using directed spray nozzles on July 1.

Plots in both trials were artificially infested with spider mites prior to initiating POST herbicide applications using infested cotton leaves. Ten infested leaves were placed in the center two rows of each plot. Trial 1 was infested on May 20 and Trial 2 on June 2. Following infestation, each trial area was sprayed with acephate insecticide (0.25 lb ai/acre during early season, and then 0.5 lb ai/acre during mid-late season) once a week until mite counts were terminated. The purpose of these insecticide applications was to encourage mite population development by destroying any natural enemies of spider mites present in the field. The center two rows of plots were scouted weekly for the presence of spider mites and plant injury symptoms. Initially, infestations were estimated using "mite hits." A "mite hit" was defined as at least one leaf showing symptoms of spider mite injury per three row-feet, so that in a 40-foot plot each row could have a maximum of 14 hits. Spider mite injury was defined as stippling or bronzing near the main leaf veins or folds in the leaf. When infestations became more common, the scouting method was switched to percent infested plants. Ten plants per plot were checked at random for symptomatic leaves and the presence of mites. Also, five (3rd expanded leaf below the terminal) random leaves were collected from each plot once a week and the mites in one square inch of each leaf were counted using a dissecting microscope.

Commonly used thresholds for miticide applications in Mississippi, where spider mites have historically been more problematic, is 40-50 percent infested plants and populations increasing (Catchot, 2010). This threshold was used to determine when to make foliar miticide applications in the sub-plots.

Ten plants per plot were mapped at first bloom and prior to harvest to determine fruit retention and distribution. All first-position fruiting positions were checked on each plant. Percent square retention was calculated at first bloom and percent boll retention was calculated for three fruiting zones (nodes 5-10, nodes 11-15, and nodes 16-20) just prior to harvest. Plant heights were also recorded at this time. University of Georgia fertility recommendations were followed for both trials. Also, the cotton was regularly scouted for stink bugs and other pests, and sprayed as needed. Growth regulator was applied as needed to control growth, and the cotton was taken to harvest. The center two rows of each plot were harvested with a spindle picker; Trial 1 on September 21 and Trial 2 on October 11; a 38 percent lint fraction was assumed in all plots to determine lint yields. Statistical analyses were performed using ANOVA and means were separated using LSD (P=0.05).

Results and Discussion

Mite Hits and Percent Infested Plants

In Trial 1 glufosinate was applied POST at the 5-leaf stage on May 24 and visible glufosinate injury from this application was 15 percent. Visible spider mite infestations measured as "mite hits" or "percent infested plants" were significantly less in the glufosinate-based herbicide system at 8, 16, and 22 days after herbicide treatment (DAHT) (Table 1). No significant differences in the percent of spider mite infested plants were observed between herbicide systems after 22 DAHT.

Table 1. Effect of glufosinate and glyphosate herbicide systems on mite hits and percent infested plants, Tift Co. GA, irrigated and conventional tillage.

Trial 1	Mite Hits			Percent Infested Plants			
	1 June	9 June	15 June	8 July	15 July	21 July	27 July
Herbicide System	8 DAHT	16 DAHT	22 DAHT	45 DAHT	52 DAHT	58 DAHT	64 DAHT
Glyphosate	4.33 b	10.25 b	79.17 b	100.00	100.00	100.00	67.50
Glufosinate	1.33 a	3.92 a	48.33 a	100.00	100.00	100.00	76.67
LSD (0.05)	1.13	3.04	14.78	n.s.	n.s.	n.s.	n.s.

*Means followed by the same letter within a column do not significantly differ (P=0.05, LSD)

In Trial 2, glufosinate was applied POST at the 2- and 7-leaf stage on June 4 and 17. Visible herbicide injury from these applications was 8 and 1 percent, respectively. Visible spider mite infestations were significantly lower in the glufosinate-based herbicide system at 12 DAHT1 and 6 and 28 DAHT2 (Table 2). No significant differences were observed between herbicide systems after 28 DAHT2. Aldicarb applied in-furrow at planting significantly reduced mite hits at 28 days after planting (DAP) and percent infested plants at 35 DAP compared with untreated miticide plots.

Table 2. Effect of glufosinate and glyphosate herbicide systems and at-plant and foliar miticide applications on mite hits and percent infested plants, Tift Co. GA, dryland and conservation tillage.

Trial 2	Mite Hits	Percent Infested Plants				
	16 June	23 June	15 July	21 July	28 July	4 Aug
Herbicide System	12 DAHT1	6 DAHT 2	28 DAHT 2	34 DAHT 2	41 DAHT 2	48 DAHT 2
Glyphosate	7.25 b	50.63 b	80.00 b	88.10	97	100
Glufosinate	1.63 a	13.75 a	26.88 a	80.00	96	100
LSD (0.05)	1.08	7.64	11.89	n.s.	n.s.	n.s.
Miticides	28 DAP	35 DAP	21 DAMT 1	0 DAMT 2	7 DAMT 2	14 DAMT 2
Untreated	5.75 b	38.75 b	65.00	95.00	99 b	100
Spiromesifen			53.75	78.80	100 b	100
Glufosinate			48.75	81.30	88 a	100
Aldicarb	2.63 a	16.25 a	46.25	81.30	100 b	100
LSD (0.05)	1.53	10.80	n.s.	n.s.	8	n.s.

*Means followed by the same letter within a column do not significantly differ (P=0.05, LSD)

Mites per Square Inch of Leaf

Significantly fewer spider mites per square inch were observed in the glufosinate-based herbicide system at 25 and 30 DAHT compared to the glyphosate-based herbicide system in Trial 1 (Table 3). No significant differences in spider mite counts were observed between herbicide systems after 30 DAHT. Miticide treatments (abamectin or glufosinate) were applied in Trial 1 on June 15, July 9, and July 21. Visible glufosinate injury was 6, 16, and 38 percent, respectively, with these applications. Significant differences in mite counts among miticide treatments were observed 8, 14, and 23 days after miticide treatment one (DAMT1) and 5 DAMT2. On each of these dates, significantly fewer spider mites were found in abamectin plots compared with the untreated. Although glufosinate applied as a miticide did not significantly reduce mite counts on any specific date, the seasonal mean was significantly lower compared with the untreated.

Table 3. Effect of glufosinate and glyphosate herbicide systems and foliar miticide applications on mites per square inch of leaf, Tift Co. GA, irrigated and conventional tillage.

Trial 1	**Mites/sq. in.**						
	18 June	23 June	30 June	8 July	14 July	20 July	
Herbicide System	25 DAHT	30 DAHT	37 DAHT	45 DAHT	51 DAHT	57 DAHT	Seasonal Mean
Glyphosate	8.22 b	5.25 b	2.00	7.25	0.87	0.10	3.95 b
Glufosinate	3.62 a	2.78 a	1.53	4.90	0.98	0.38	2.37 a
LSD (0.05)	2.04	2.09	n.s.	n.s.	n.s.	n.s.	0.72
Miticides	3 DAMT 1	8 DAMT 1	15 DAMT 1	23 DAMT 1	5 DAMT 2	11 DAMT 2	Seasonal Mean
Untreated	7.35	5.60 b	2.88 b	8.43 b	1.53 b	0.23	4.34 c
Abamectin	5.08	2.53 a	0.78 a	3.63 a	0.45 a	0.05	2.09 a
Glufosinate	5.33	3.93 ab	1.65 ab	6.18 ab	0.80 ab	0.45	3.06 b
LSD (0.05)	n.s.	2.56	1.35	3.28	0.84	n.s.	0.89

*Means followed by the same letter within a column do not significantly differ (P=0.05, LSD)

In Trial 2, there were significantly fewer spider mites per square inch in the glufosinate herbicide system compared with the glyphosate system 13, 21, 27, and 34 DAHT2 (Table 4). Miticide treatments (spiromesifen and glufosinate) were applied in Trial 2 on June 25 and July 21. Visible glufosinate injury was 2 and 18 percent, respectively, with these applications. At 14 DAMT1 (50 DAP), spider mite counts were significantly lower in all miticide treatments compared with the untreated control. At 27 DAMT1 (62 DAP), mite counts were significantly lower in the spiromesifen and aldicarb treatments than in the untreated control. At 7 DAMT2, spider mite numbers were significantly lower in the spiromesifen and glufosinate treatments than in the untreated control, but not in the aldicarb treatment.

Table 4. Effect of glufosinate and glyphosate herbicide systems and at-plant and foliar miticide applications on mites per square inch of leaf, Tift Co. GA, dryland and conservation tillage.

Trial 2	**Mites/sq. in.**						
	30 June	8 July	14 July	21 July	28 July	4 Aug	
Herbicide System	13 DAHT2	21 DAHT2	27 DAHT2	34 DAHT2	41 DAHT2	48 DAHT2	Seasonal Mean
Glyphosate	0.16 b	1.18 b	4.35 b	5.44 b	8.50	3.14 a	3.79
Glufosinate	0.04 a	0.01 a	1.51 a	2.74 a	9.61	6.16 b	3.35
LSD (0.05)	0.08	0.66	1.42	1.56	n.s.	1.44	n.s.
Miticides	5 DAMT1 42 DAP	13 DAMT1 50 DAP	19 DAMT1 56 DAP	26 DAMT1 63 DAP	7 DAMT2	14 DAMT2	Seasonal Mean
Untreated	0.20	1.63 b	3.75	6.04 b	10.78 b	4.63	4.50 b
Spiromesifen	0.10	0.43 a	2.93	3.30 a	6.43 a	3.76	2.82 a
Glufosinate	0.00	0.15 a	2.55	4.11 ab	5.85 a	4.43	2.85 a
Aldicarb	0.10	0.18 a	2.50	2.91 a	13.18 b	5.78	4.11 b
LSD (0.05)	n.s.	0.93	n.s.	2.21	4.03	n.s.	0.92

*Means followed by the same letter within a column do not significantly differ (P=0.05, LSD)

Plant Mapping and Yield

In Trial 1, first position square retention at first bloom was similar among herbicide systems and miticide treatments (Table 5). Boll retention at harvest was also similar between herbicide systems. However, boll retention in the 11-15 node zone was significantly lower in the glufosinate miticide treatment than in the abamectin miticide treatment and the untreated control. Yield was not significantly different between herbicide systems, but was significantly lower in the glufosinate miticide treatment compared with the abamectin miticide treatment and the untreated control. Where abamectin was used as a miticide, yield was significantly higher than the untreated control (P=0.1, LSD). Also, when measured at harvest, plants treated with glufosinate as a miticide were significantly taller than plants treated with abamectin or plants in the untreated control. There was no difference in plant height between herbicide systems.

Table 5. Effect of glufosinate and glyphosate herbicide systems and foliar miticide applications on first position square retention and plant height at first bloom, first position boll retention and plant height at harvest, and lint yield, Tift Co. GA, irrigated and conventional tillage.

Trial 1	Percent Square Retention	Percent Boll retention			Plant Height (cm)		Yield (lbs./acre)
Herbicide System	Nodes 5-14	Nodes 5-10	Nodes 11-15	Nodes 16-20	First Bloom	Harvest	38 % turnout
Glyphosate	95.00	76.53	44.50	15.47	84	97	1546
Glufosinate	93.30	74.58	46.00	15.86	84	96	1599
LSD (0.05)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Miticides							
Untreated	94.25	72.29	48.50 a	13.85	82	91 b	1590 a
Abamectin	93.84	76.67	50.00 a	15.79	84	95 b	1733 a
Glufosinate	94.36	77.71	37.25 b	17.35	85	104 a	1395 b
LSD (0.05)	n.s.	n.s.	9.21	n.s.	n.s.	6	155

*Means followed by the same letter within a column do not significantly differ (P=0.05, LSD)

In Trial 2, there were no significant differences in first position square retention at first bloom or boll retention at harvest between herbicide systems or among miticide treatments (Table 6). There were also no differences in plant heights among any of the treatments. Yield was not significantly different between herbicide systems. Yields were not significantly different among the miticide treatments spiromesifen, glufosinate, and aldicarb, but all of these treatments had significantly higher yields than the untreated control.

Table 6. Effect of glufosinate and glyphosate herbicide systems and at-plant and foliar miticide applications on first position square retention and plant height at first bloom, first position boll retention and plant height at harvest, and lint yield, Tift Co. GA, dryland and conservation tillage.

Trial 2	Percent Square Retention	Percent Boll Retention			Plant Heights (cm)		Yield (lbs lint/acre)
Herbicide System	Nodes 6-14	Nodes 6-10	Nodes 11-15	Nodes 16-20	First Bloom	Harvest	
Glyphosate	95.07	79.00	38.43	3.24	79	93	1026
Glufosinate	95.26	79.13	36.63	4.41	78	92	1037
LSD (0.05)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Miticide							
Untreated	94.92	81.50	37.25	3.92	76	90	943 b
Spiromesifen	95.39	79.00	39.50	3.84	81	92	1083 a
Glufosinate	96.17	76.75	36.86	3.80	80	93	1057 a
Aldicarb	94.19	79.00	36.50	3.75	78	94	1042 a
LSD (0.05)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	94

*Means followed by the same letter within a column do not significantly differ (P=0.05, LSD)

Trial 1 was conducted in an irrigated conventional tillage environment. Weed control was excellent and included a PRE herbicide application of pendimethalin, cultivation, a POST application of either glyphosate or glufosinate at the 5-leaf stage, and a lay-by application of glyphosate and diuron. Trial 2 utilized conservation tillage practices in a dryland environment and weed control was acceptable. Two POST applications of either glyphosate or glufosinate at the 2 and 7 leaf stages were used in addition to a glyphosate and diuron lay-by application.

Summary

Glufosinate applied during the seedling stage reduced spider mite plant injury symptoms and infestations for 22-34 days after herbicide treatment. Glufosinate applied POST at the 5-leaf stage in Trial 1 reduced percent spider mite infested plants for 22 DAHT. In trial 2, glufosinate applied at the 2- and 7-leaf stages reduced percent infested plants for 28 DAHT. Spider mite populations (mites per square inch) were reduced for 30 and 34 DAHT in the glufosinate based herbicide system in Trials 1 and 2, respectively. In Trial 2, aldicarb reduced percent infested plants and mites per square inch for 35 and 50 days after planting.

Spider mites were artificially infested in these trials prior to the first POST herbicide applications. Glufosinate used as a POST herbicide and aldicarb used in-furrow at planting delayed the buildup of resident spider mite populations in these trials. Glufosinate and aldicarb are toxic to spider mites (Ahn et al, 1997). Utilization of these technologies in commercial production systems reduces the risk of early and mid-season spider mite infestations. In a situation where spider mites could potentially become a problem, all options for management should be considered. This is especially important with the pending cancellation of aldicarb which is commonly used by Georgia growers for early season thrips control. Alternative preventive treatments for thrips are not as active and do not provide the residual control of thrips observed with aldicarb (Roberts, 2006). Thus foliar thrips insecticide applications may be needed on a more widespread basis which will increase the risk of spider mite infestations. The use of a glufosinate-based herbicide program would offset some of this risk.

The miticides spiromesifen and abamectin provided more consistent control of spider mites than glufosinate when applied during mid-season. Results demonstrated that spider mites may be an economic pest of cotton in Georgia. A significantly higher yield was observed in the dryland trial where foliar applications of spiromesifen were applied during mid-season. In the irrigated trial, significantly (P=0.1) higher yields were observed where abamectin was applied during mid-season.

PHY 375 WRF cotton can be injured by glufosinate to the point that yield is significantly reduced. Glufosinate injury ranged from 6-38 percent in Trial 1 and 1-18 percent in Trial 2. Higher crop injury ratings were observed following post-bloom applications of glufosinate. Glufosinate was applied as a miticide for the last time in both trials on July 21, which was during the fourth week of bloom in Trial 1 and during the second week of bloom in Trial 2. The highest injury ratings in both trials, 38 percent in Trial 1 and 18 percent in Trial 2, were observed after this application. No significant differences in yield were observed between herbicide systems. However, glufosinate applied as a miticide significantly reduced yield in Trial 1. No significant differences were observed in first-position square retention in either trial. However, first-position boll retention was significantly reduced at nodes 11-15 in Trial 1. Reduced boll retention in this zone is likely the result of glufosinate injury and may explain the yield reduction observed. No significant yield reduction was observed in the glufosinate miticide treatment in Trial 2. In this trial, glufosinate, spiromesifen, and aldicarb significantly increased yield when applied as miticides.

References

Ahn, Y., J. Cho, Y. Kim, J. Yoo, and J. Lee. 1997. Toxicity of the herbicide glufosinate-ammonium to *Tetranychus urticae* (Acari: Tetranychidae) under laboratory and field conditions. Pestic. Sci. 51:455-461.

Bartlett, B. 1968. Outbreaks of Two-Spotted Spider-Mites and Cotton Aphids Following Pesticide Treatment. I. Pest Stimulation vs. Natural Enemy Destruction as the Cause of Outbreaks. J. Econ. Entomol. 61(1):297-303.

Catchot, A. (rev.). 2010. Insect Control Guide for Agronomic Crops. Publication 2471. Mississippi State University. Starkville, MS.

Culpepper, S., A. York, P. Roberts, and J. Whitaker. 2009. Weed control and crop response to glufosinate applied to 'PHY 485 WRF' cotton. Weed Technol. 23:356-362.

Frans, R.E., R. Talbert, D. Marx, and H. Crowley. 1986. Experimental design and techniques for measuring and analyzing plant responses to weed control practices. Pp. 29-46 *In* N.D. Camper, ed. Research Methods in Weed Science. Champaign, IL: Southern Weed Science Society.

Reddall, A., V. Sadras, L. Wilson, and P. Gregg. 2004. Physiological responses of cotton to two-spotted spider mite damage. Crop Sci. 44:835-846.

Roberts, P. 2006. Three year summary of Cruiser, STAN, and combinations for early season thrips control. 2006 Beltwide Cotton Conferences Proceedings. 1580-1582.

Steinkraus, D., J. Zawislak, G. Lorenz, B. Layton, and R. Leonard. Spider mites on cotton in the Midsouth. University of Arkansas Division of Agriculture. Fayetteville, AR.

Wilson, L. 1993. Spider mites (Acari: Tetranychidae) affect yield and fiber quality of cotton. J. Econ. Entom.. 86(2):566-585.