RENIFORM NEMATODE MANAGEMENT LINKED TO VARIABLE RATE HERBICIDE APPLICATIONS

Dustin M. Herring
K. S. Lawrence
C. H. Burmester
Auburn University Dept. of Agronomy and Soils
Auburn, Alabama
J. Kloepper
Auburn University Dept. of Entomology and Plant Pathology
Auburn, Alabama

Abstract

Herbicide applications were applied to harvested cotton to reduce cotton re-growth and eliminate potential winter weeds aiming to reduce populations of *Rotylenchulus reniformis* for the following season. Tests were first conducted in the greenhouse and then in three field trials in to evaluate the effect of herbicides on weed densities, re-growth of harvested cotton, and *R. reniformis* nematode populations, Treatments were: 1) 2, 4-D Amine 0.75 Q/A 2)2, 4-D Amine 1.0 Q/A, 3) Clarity® Dicamba 0.75 Q/A, 4) Clarity® Dicamba 1.0 Q/A, and 5) untreated control arranged in a random complete block design. In the green house, herbicide applications were applied at 120 days after planting (DAP) following stalk cutting which simulated harvest. In the field, herbicides were applied immediately after harvest and *R. reniformis* nematode population samples were taken at 30-day intervals. Green house data indicated a reduction in plant height, root and shoot weight and populations among the herbicide treatments as compared to the untreated control. *Rotylenchulus reniformis* populations at cotton planting and harvest were statistically similar to the herbicide applications as compared to the untreated control. Field data indicated that herbicide applications preformed as well as the control related to yield. An economic analysis indicated a positive financial return using 2, 4-D over the untreated control in both years of the study.

Introduction

The reniform nematode *(Rotylenchulus reniformis)* is one of the South's most economically damaging pests. The reniform nematode has evolved into the primary pest of cotton production in the southeast United States. Over the last two decades, the percent of cropland infested with this nematode has been rapidly enlarging. To date, the reniform nematode one of the most economically detrimental cotton pest in Alabama, Louisiana, and Mississippi where losses of $14,680,716, $4,000,971, and $15,112,500 were reported in 2008. Currently, no commercially available cotton cultivars provide resistance to the reniform nematode (Usery et al., 2006). Therefore, most management options for nematodes involve the use of nematicides. Multiple nematicide efficacy tests across the cotton belt have reported suppression of reniform populations for the first half of the season with increase yields compared to untreated control in most fields (Robinson, 2007). Unfortunately, nematicides are considered to only be a short-term solution, with nematode population densities repopulating by the end of the growing season. Rebounding populations often require that these products be applied year after year, at a cost both to the farmer but also to the environment. This extensive use of nematicides is also a risk to sustainable agriculture and a summary of recent nematicide tests in Alabama highlighted the inconsistency of these treatments to produce increases in cotton yield (Burmester et al, 2007). The use of crop rotation offers an alternative for managing plant-parasitic nematodes and has been shown to reduce nematode populations in one season (Gazaway et al, 2007). However, reniform populations often return to damaging levels after one season of cotton rotation. Plus, greenhouse trials indicated that the majority of dicotyledonous weed species common to the southern cotton region serve as host to *R. reniformis* (Davis and Webster, 2005; Lawrence et al., 2007). This means that even non-host crops may not provide adequate management of this pest. With all this in mind, a farmer's goal is to reduce *R. reniformis* populations before planting and maintain populations below the damage threshold during the growing season. A strategy to reduce population before planting is to eliminate postharvest cotton re-growth as well as treating potential winter weeds. It has been theorized that cotton re-growth which typically occurs for several weeks after harvest allows additional multiple generations of *R. reniformis*. Herbicide applications could prove to be an effective nematode management control strategy. This approach incorporated with other management systems could lead to lower *R. reniformis* populations at planting date the following season.

Materials and Methods

Initial testing was done in a green house setting. Stoneville (ST) 5599 BR cotton was planted in autoclaved sandy loam soil (67.5, 20, 12.5% S-S-C) contained in individual 500cm³ pots. Tests were arranged in a random complete block design and were repeated three times. Treatments were as follows: 1) 2, 4-D Amine 0.75 Q/A 2)2, 4-D Amine 1.0 Q/A, 3) Clarity® Dicamba 0.75 Q/A, 4) Clarity® Dicamba 1.0 Q/A. At planting, reniform populations were added to the pots at 2000 life stages/500cm³. Cotton was grown in the green house for 120 days then a simulated harvest was conducted by cutting the cotton stalks at a height of approximately six inches. Herbicide applications were applied following the simulated harvest and plants were placed back into the green house where they grew for 60 days. After 60 days, cotton was removed from the green house and cotton re-growth data was collected. Here we observed dry root weight, dry shoot weight, and nematode populations from soil and plant roots. Reniform populations were determined through soil and root extraction. Soil extraction included gravity sieving followed by sucrose centrifugation. Roots were extracted in 0.6% NaOCl solution. Populations and re-growth data was then statistically analyzed using the general linear models procedure (PROC GLM) in SAS and means were compared using Fisher's protected least significance test at ($P \leq 0.05$).

Following our green house study, test plots were established in fall 2008 at three locations in Alabama known for having a history of high populations of *R. reniformis*. One test was conducted in Escambia County and two tests were conducted in Macon County. Plots were in a random complete block design with five treatments and four replications at each location. Harvested cotton was cut using a conventional stalk cutter and herbicide applications were applied. Herbicide applications were sprayed with a two row backpack sprayer. Treatments were as follows: 1) 2, 4-D Amine 0.75 Q/A 2)2, 4-D Amine 1.0 Q/A, 3) Clarity® Dicamba 0.75 Q/A, 4) Clarity® Dicamba 1.0 Q/A. Following herbicide applications to the harvested cotton, reniform soil samples were taken over the winter to observe population growth. At planting in the spring of 2009 soil samples began to monitor at planting populations as well as population increases over the growing season. Each replication was planted with a four row planter with the center two rows used for sampling and the outer two rows servings as border rows. At harvest in 2009, *R. reniformis* populations were observed as well as yield data from the herbicide plots. Cotton was harvested either by hand or with a plot harvester depending on location. Population and yield data was then statistically analyzed using the general linear models procedure (PROC GLM) in SAS and means were compared using Fisher's protected least significance test at ($P \leq 0.1$).

An economic analysis was performed on the yield data from 2008 and 2009. Lint yield was averaged from each treatment and multiplied by $0.55 (avg. cotton price) indicating a potential gross profit/acre. The herbicide cost/acre was subtracted from our potential gross/acre determining the estimated net/acre related to each specific herbicide treatment. To determine whether our herbicide applications were economically feasible compared to the untreated control, which cost a producer $0.00/acre, we subtract the net/acre value associated with the control from each herbicide application net/acre value. This concluded the financial profit over control associated with herbicide applications.

[(Lint yield*$0.55) – (Herbicide cost/acre)] = Herbicide trt. net/acre
(Herbicide trt. net/acre – Control net/acre) = Profit over Control

Results and Discussion

Green house data indicated cotton re-growth was inhibited ($P \leq 0.05$) among all four herbicide applications compared to the untreated cut stalk control as related to root and shoot dry weight (Table 1). Both *R. reniformis* vermiform and egg populations collected from the soil were also lower in all four herbicide treatments as compared to the cut stalk control (Table 2). Thus proving *R. reniformis* populations do continue to increase on re-growth cotton. When populations were extracted from the cotton roots, *R. reniformis* egg populations were lower ($P \leq 0.05$) in the herbicide applications compared to the cut stalk control. Specifically, 2,4-D at 0.75 Q/A and Clarity® (Dicamba) at 1.0 Q/A produced vermiform population significantly lower than the control and all herbicides reduced the number of eggs extracted from the total root system. Although, the number of *R. reniformis* eggs/gram of root indicated 2, 4-D at 0.75 Q/A and Clarity® Dicamba at 1.0 Q/A produced lower populations ($P \leq 0.05$) versus the control. Thus in the greenhouse, *R. reniformis* populations were reduced by 2,4-D at 0.75 Q/A and Clarity®

(Dicamba) at 1.0 Q/A and increased in the cut stalk control confirming nematode populations continue to increase on harvested cotton re-growth but those populations can be reduced by herbicide applications aimed at killing the cotton plant.

Table 1. Effect of herbicides applied to cotton in the greenhouse on plant growth parameters at 60 days after application.

Herbicide	Rate	Plant growth parameters: Plant height (cm)	Shoot dry weight (gm)	Root dry weight (gm)
2,4-D Amine	0.75 qt/a	15.2	2.2 b	1.1 b
2,4-D Amine	1.0 qt/ a	15.1	2.7 b	1.1 b
Clarity	0.75 qt/a	15.7	1.9 b	1.3 b
Clarity	1.0 qt/ a	16.2	1.8 b	1.0 b
Check	- -	16.5	14.6 a	3.5 a
LSD ($P\leq .05$)		1.97	1.36	0.5

[x] No interactions over time were observed for plant growth parameters thus data was combined for analysis. Means represent 8 replications of each treatment.

Table 2. Effect of herbicides applied to cotton in the greenhouse on *Rolylenchulus reniform* populations extracted from the soil and the plant root system.

		Soil [x]		Roots		
Herbicide	Rate	Vermiform life stages [z]	Eggs	Vermiform life stages	Eggs	Total eggs/gm root [y]
2,4-D Amine	0.75 qt/a	8,227 b	12,746 b	3,148 bc	677 b	354.6 b
2,4-D Amine	1.0 qt/ a	8,894 b	22,721 b	3,843 abc	2,319 b	653.1 ab
Clarity	0.75 qt/a	7,754 b	21,398 b	4,139 ab	2,898 b	690.6 ab
Clarity	1.0 qt/ a	7,213 b	9,000 b	1,651 c	967 b	302.5 b
Check	- -	15,074 a	66,927 a	5,543 a	34,899 a	1,425.3 a
LSD ($P\leq 0.05$)		4,690	24,626	2,271	24722	777.5

[x] No interactions over locations were observed for nematode levels thus data was combined for analysis. Means represent 12 replications of each treatment.
[y] Total number of eggs from the soil and root system expressed per gram of fresh root.
[z] Nematode numbers recovered from soil in each pot.

Date of Planting (DAP) Samples and Harvest Population Samples

Field trials were initiated at harvest in 2007 with the application of the herbicides. Reniform nematode samples taken in the fall and winter were quite variable and little differences in reniform populations could be found due to treatments (Table 3). Reniform nematode levels at planting, however, were highest in the check treatment indicating a possible reduction in nematodes due the fall herbicide applications. Both 2, 4-D and Clarity at the 0.75 and 1 Q/A rates supported lower populations of *R. reniformis* than the plots with cut cotton stalks and no herbicide application in 2008. By harvest in October of 2008 the nematodes numbers were similar across the field. The herbicide application appeared to affect numbers at planting but not throughout the cotton growing season. However, in 2009, all but herbicide applications other than 2, 4-D Amine 1.0 Q/A produced only numerically lower *R. reniformis* populations at cotton planting as compared to the control (Table 3). Cotton was planted 3 to 4 weeks later in 2009 than in 2008 due to the wet spring experienced in the region which may have affected the nematode numbers. Populations at harvest in 2009 were similar between all plots similar to the nematode numbers in 2008.

Table 3. Effect of herbicides applied to cotton at harvest on *Rolylenchulus reniform* populations in three field locations in north, central, and southern Alabama n 2008.

Herbicide [x]	Rate	**Cotton planting 2008** [y] *Rotylenculus reniformis/150 cm³ soil*	**Cotton harvest 2008** *Rotylenculus reniformis/150 cm³ soil*
24DL	0.75 qt/a	2195	1590
24DH	1.0 qt/ a	2249	1944
CLARITYL	0.75 qt/a	1854	1815
CLARITYH	1.0 qt/ a	2575	2073
CK	- -	4532	2105
LSD (P≥ 0.10)			

[x] No interactions over locations were observed for nematode levels thus data was combined for analysis. Means represent 12 replications of each treatment.
[y] Nematode numbers recovered from soil samples.

Table 4. Effect of herbicides applied to cotton at harvest on *Rolylenchulus reniform* populations in three field locations in north, central, and southern Alabama in 2009.

Herbicide [x]	Rate	Cotton planting 2009 [y] *Rotylenculus reniformis/150 cm³ soil*	Cotton harvest 2009 *Rotylenculus reniformis/150 cm³ soil*
24DL	0.75 qt/a	1242	2086
24DH	1.0 qt/ a	1178	2079
CLARITYL	0.75 qt/a	1133	2375
CLARITYH	1.0 qt/ a	1551	2890
CK	- -	1378	3972
LSD (P≥ 0.10)		638.5	2270.1

[x] No interactions over locations were observed for nematode levels thus data was combined for analysis. Means represent 12 replications of each treatment.
[y] Nematode numbers recovered from soil samples.

Harvest Cotton Yield Data

Cotton yields were numerically higher in the plots treated with the herbicide applications in 2008 and 2009. Cotton yield in the 2, 4-D at 1 Q/A and both Dicamba treatments over all locations averaged a 47 lb/A increase as compared to the control; however, the yield boost was not significant (P ≤ 0.10). In 2009 similar trend were observed. All the 2, 4-D and both Dicamba treatments produced an increased seed cotton yield of 196 lb/A. Again the increase was not significant as in 2008.

Table 5. Seed cotton yield as influenced by fall herbicides to reduce *Rotylenchulus reniformis* numbers at cotton planting.

Herbicide [x]	Rate	2008 Seed cotton lb/A	2009 Seed cotton lb/A
24DL	0.75 qt/a	**2507**	**2295**
24DH	1.0 qt/ a	**2563**	**2361**
CLARITYL	0.75 qt/a	**2524**	**2380**
CLARITYH	1.0 qt/ a	**2518**	**2320**
CK	- -	**2482**	**2143**
LSD (P≥ 0.10)		**214.5**	**329.3**

[x] No interactions over locations were observed for yield thus data was combined for analysis. Means represent 12 replications of each treatment.

Economic Yield Analysis

Seed cotton yields were numerically greater in all herbicide plots compared to the control. Positive financial profit/acre over control was only observed in the 2, 4-D plots. The combined average data from all tests showed an increase in net profit for both the high and low rates of 2, 4-D (Table 6). The increase in profit/acre over the control was $2.09 and $15.19, respectively for the low and high rates of 2, 4-D in 2008. Although yields were increased in the Clarity treatments the cost of the herbicide eliminated the profit over the control. In 2009, yields again were higher in all herbicide applications compared to the control. Again, only the 2, 4-D herbicide applications produced positive profit/acre over the control. Also, both Clarity applications produced losses/acre compared with the untreated control.

Table 6. Economic analysis of the fall herbicide applications in *Rotylenchulus reniformis* infested fields.

2008						
Herbicide	**Yield Lb/A**	**Lint lb/Acre**	**Bales/Acre**	**Cost/Acre**	**Net/Acre**	**Profit Over Control**
24DL	2507.2	1002.88	2.09	$3.50	$548.08	$2.09
24DH	2562.8	1025.12	2.14	$2.63	$561.19	$15.19
CLARITYL	2524.1	1009.64	2.10	$22.50	$532.80	-$13.19
CLARITYH	2517.8	1007.12	2.10	$16.88	$537.04	-$8.96
CK	2481.8	992.72	2.07	$0.00	$546.00	N/A
2009						
Herbicide	**Yield Lb/A**	**Lint lb/Acre**	**Bales/Acre**	**Cost/Acre**	**Net/Acre**	**Profit Over Control**
24DL	2317.3	926.92	1.93	$3.50	$506.31	$9.81
24DH	2295.4	918.16	1.91	$2.63	$502.36	$5.86
CLARITYL	2358.4	943.36	1.97	$22.50	$496.35	-$0.15
CLARITYH	2270.3	908.12	1.89	$16.88	$482.59	-$13.91
CK	2256.8	902.72	1.88	$0.00	$496.50	N/A

Conclusions

Cut cotton stalks treated with herbicide applications have potential to produce lower overwintering populations of *R. reniformis* for the spring cotton planting season. *Rotylenchulus reniformis* samples taken at planting evidenced that herbicide applications may reduce populations by reducing fall generations as compared to the untreated control. Most importantly, yields in the herbicide application plots were higher in both years as compared to the untreated control. Yield data reveals lbs/acre gains linked to the herbicide applications. More lbs/acre leads to more $/acre for the producer.

References

Blassingame, D., W. Gazaway, M. Olson, T. Kirpatrick, M. Davis, R. Sprenkel, B. Kermerait, P. Colyer, G. Scuimbato, A. Wrather, N. Goldberg, S. Koenning, J. Banks, J. Muller, M. Newman, J. Woodward, and P. Phipps. 2007, Cotton pest loss estimate committee report. National Cotton Council of American.

Burmester, C.H., K.S. Lawrence, W.S. Gazaway, R. Adridge, B. Freeman, D. Derrick, W. Griffith, M..Hall, L. Kuykendall and H. Potter. 2007. Summary of Nematicide Seed Treatments in Alabama Cotton Trials. March Timely Information, Agronomy and Soils Series. Ala. Coop. Ext. Ser. http://www.aces.edu/timelyinfo/#Plant

Jones, J. R., K. S. Lawrence, and G. W. Lawrence 2006. Use of winter cover crops in cotton cropping for management of Rotylenchulus reniformis. Nematropica 36: 53-66.

Lawrence, K. S. A. J. Price, G. W. Lawrence, J. R. Jones, and R. Akridge. 2007. Several common weeds support reniform nematode (*Rotylenchulus reniformis*) reproduction in cotton-corn rotations. #1459. *In* World Cotton Conference-4, 10-14 Sept. 2007, Lubbock, TX, U.S.