THE COMPOUDNING STRESSES OF TOBACCO THRIPS, *FRANKINELLA FUSCA*, AND RENIFORM NEMATODES, *ROTYLENCHULUS RENIFORMIS*, ON COTTON

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Abstract

Tobacco thrips and reniform nematode are important pests of cotton production systems. Both pests have the potential to cause early season damage to cotton seedlings and stunt growth and delay maturity resulting in lower yields. Field studies were conducted in 2015 and 2016 in Hamilton, MS to evaluate treatments for the control of tobacco thrips and reniform nematode. A randomized complete block design with a split-split plot arrangement was used. Treatments consisted of no-till and conventional tillage; at-planting applications of imidacloprid plus thiodicarb, imidacloprid, thiamethoxam plus abamectin, thiamethoxam, aceptate plus terbufos, aldicarb, and an untreated control; and no nematicide and 1, 3- dichloropropene. There were no significant three way interactions of any factors. In regards to nematode populations, there were no differences for any main effect treatments until the post-harvest sample where there was a two way interaction between tillage and nematicide that resulted in a reduction of the population in the conventional tillage where a nematicide was used. Treatments containing acephate plus terbufos or aldicarb had the lowest thrips densities, and damage rating with the highest plant vigor at the 3-4 leaf stage. Thrips damage and densities were also reduced in no-tillage treatments compared to the conventional tillage. While early-season plant responses were measurable, due to optimal fall conditions the crop had the ability to compensate for early-season stresses, resulting in no significant difference in yield with tillage or at-planting applications, however no nematicide treatments yielded higher than nematicide treatments.

Introduction

The early-season pest complex in cotton production systems can be made of up of a many different species. In Mississippi tobacco thrips, *Frankliniella fusca* (Hinds), and reniform nematode, *Rotylenchulus reniformis* (Linford and Oliverira), are two commonly found pests that have the ability to significantly impact yields. Across the United States cotton belt, tobacco thrips are a consistent and predictable pest that cause injury to cotton until the fourth or fifth true leaf (Toews et al. 2010). Thrips symptomology includes crinkling of leaves, a silvery appearance, or loss of apical dominance (Cook et al. 2011, Telford and Hopkins 1957, Reed and Reinecke 1990). In addition to above ground symptomology, several studies suggest thrips damage can negatively impact early growth and development of roots (Roberts and Rechel 1996, Watts 1937, Carter et al. 1989). Reniform nematode is a semi-endoparasitic pest that feeds on the cortex of the roots, which results in limiting the roots ability to uptake water and nutrient while that may increase the susceptibility of cotton to soil borne diseases (Koenning et al. 2004). Issues pertaining to nematodes are often attributed to nutrient deficiencies because of similar above ground symptomology. Thrips and nematode damage can result in reduced plant heights, delayed plant maturity, or even reduced yields. Depending on the environmental conditions throughout the season, it is possible to have some recoverability following early season plant stress depending on the time and severity of the injury (Roberts and Rechel 1996, Watts 1937, Carter et al. 1989).

Materials and Methods

Field experiments with two site years were conducted in Hamilton, MS during 2015 and in 2016 to evaluate the influence of tillage, seed treatment, and nematicide on the control of tobacco thrips and reniform nematode. The field study was implemented as a randomized complete block design with a split-split plot treatment arrangement with four replications. The main-plot factor included two levels of land preparation: conventional tillage and no-tillage. Conventional tillage treatments were subsoiled 48 to 51-cm on 9 Apr 2015 and 16 Apr 2016. Immediately following subsoiling, tilled plots were bedded with a four row hipper/bedding implement. The sub-plot factor included two levels of a nematicide: 1, 3-dichloropropene (Telone II, Dow AgroSciences, Indianapolis, IN) at 28 L ha^{-1} and no nematicide. Nematicide applications of 1, 3-dichloropropene were made on 5 May 2015 and 19 Apr 2016 using a four-row coulter injection system. The sub-sub-plot factor included six levels of at-planting insecticide: imidacloprid (Gaucho 600, Bayer CropScience, Research Triangle Park, NC) at 0.375 mg ai $seed^{-1}$, imidacloprid plus thiodicarb (Aeris, Bayer CropScience, Research Triangle Park, NC) at 0.375 plus 0.75 mg ai $seed^{-1}$, thiamethoxam (Cruiser 5FS, Syngenta Crop Protection Inc., Greensboro, NC) at 0.34 mg ai $seed^{-1}$, thiamethoxam plus abamectin (Avicta Duo Cotton, Syngenta Crop Protection Inc., Greensboro, NC) at 0.34 plus 0.49 mg ai $seed^{-1}$, acephate (Orthene 97, AMVAC Chemical Corporation, Los Angeles, CA) at 3.9 g ai kg^{-1} of seed plus terbufos 75.7 g ai ha (2015) (Counter 15G, AMVAC Chemical Corporation, Los Angeles, CA) or aldicarb (AgLogic 15G, AgLogic LLC, Chapel Hill, NC) at 340.5 g ai ha^{-1} (2016), and an untreated control. All seed were treated with a fungicide to minimize any effects from seedling disease. The granular insecticides terbufos and aldicarb were applied directly into the seed furrow at the time of planting. All other at-planting insecticides were applied as seed treatments. Sub-sub-plots were four 3.8-m rows measuring 15.24-m in length. Cotton seed were planted at a depth of approximately 2-cm at a population of 135,850 seed ha^{-1} on 12 May 2015 and 10 May 2016. Standard production practices were followed according to Mississippi State University Extension Service recommendations.

Nematode populations were estimated by collecting ten, 20-cm deep soil cores from individual plots using a 2.5 cm diameter soil sampling probe. Cores were combined, and a sub-sample of 500 cm^3 was processed by the Mississippi State University Extension Plant Diagnostic Lab in Starkville, MS using a semi-automatic elutriator. Nematode samples were collected prior to the nematicide application, at first square, and post-harvest. Thrips damage ratings and thrips densities were evaluated at the 3-4 leaf stage. Damage ratings were recorded on a scale of 0 (no injury) to 5 (severe injury). Thrips densities were estimated by randomly cutting five plants at ground level and placing them into a 0.47-L glass jar with a 50% ethanol solution. Plants were rinsed with a 50% ethanol solution and the remaining solution was poured through a Buchner funnel. Thrips adults and nymphs were collected on filter paper and that paper was placed into a Petri dish for counting under a microscope. Adult thrips darker in color were considered to be tobacco thrips due to the observations of Stewart et al. (2013) where 98% of thrips species in Mississippi were determined to be tobacco thrips. Immature thrips were marked as immatures, because they cannot be identified to species. Plant vigor was assessed at the 3-4 leaf stages on a scale of 1 (poor stand) to 10 (excellent, uniform stand). Total above and below ground biomass samples were evaluated by uprooting five random plants from the outer two rows at the 4-leaf stage. Above and below ground portions of the five uprooted plants were placed into bags and dried in an air dryer for 48 hours at 38°C. After drying, samples were weighted to determine dry biomass. Cotton yields were determined by harvesting the center two rows of each plot modified spindle-type cotton picker for small plot research.

Data were analyzed using analysis of variance (PROC GLIMMIX, SAS 9.4; SAS Institute; Cary, NC). Year and replication were considered to be random effects, and tillage, nematicide, and seed treatment were considered to be fixed effects. Means were separated using Fisher's Protected LSD procedure at the 0.05 level of significance.

Figures and Tables

Table 1. Post-harvest nematode sample interaction

Treatment		Density
No Tillage	No 1,3-Dichloropropene	3879 ab
Tillage	1,3-Dichloropropene	3276 b
No Tillage	1,3-Dichloropropene	4278 ab
Tillage	No 1,3-Dichloropropene	3276 b
p-value		0.043

Table 2. Thrips densities per five plants at the 3-4 leaf stage

Treatment	Immatures	Adults
No Tillage	12.91 b	5.28 b
Tillage	19.27 a	7.46 a
p-values	0.0004	0.0442
Untreated Control	16.98 cd	7.94 ab
Thiamethoxam	25.73 a	9.84 a
Thiamethoxam plus abamectin	24.65 ab	10.31 a
Imidacloprid	19.97 bc	5.7 b
Imidacloprid plus thiodicarb	12.86 de	7.74 ab
Acephate plus terbufos	8.56 ef	1.34 c
Aldicarb	3.86 f	7.45 ab
p-values	0.0001	0.0001

Table 3. Thrips damage ratings and plant vigor at the 3-4 leaf stage

Treatment	Damage	Vigor
No Tillage	2.69 b	5.08 b
Tillage	2.79 a	6.12 a
p-values	0.0001	0.0001
No 1,3-Dichloropropene	2.62 b	5.57 a
1,3-Dichloropropene	2.87 a	5.63 a
p-values	0.0466	NS
Untreated Control	4.04 a	4.90 e
Thiamethoxam	3.55 a	4.81 e
Thiamethoxam plus abamectin	3.25 b	5.13 d
Imidacloprid	2.89 c	5.33 d
Imidacloprid plus thiodicarb	2.71 c	5.61 c
Acephate plus terbufos	1.79 d	6.24 b
Aldicarb	0.95 e	7.18 a
p-values	0.0001	0.0001

Table 4. Total plant biomass and cotton yield

Treatment	Total Biomass	Yield
	Grams	Kg Ha
No Tillage	3.55 b	1228 a
Tillage	5.29 a	1203 a
p-values	0.0001	NS
No 1,3-Dichloropropene	4.21 b	1252 a
1,3-Dichloropropene	4.63 a	1180b
p-values	0.0076	0.0001
Untreated Control	3.61 c	1213 a
Thiamethoxam	3.77 c	1242 a
Thiamethoxam plus abamectin	4.35 b	1212 a
Imidacloprid	4.12 bc	1198 a
Imidacloprid plus thiodicarb	4.41 b	1230 a
Acephate plus terbufos	5.46 a	1228 a
Aldicarb	5.24 a	1187 a
p-values	0.0001	NS

Results and Discussion

Nematode population prior to the application of a nematicide were significantly reduced from 1704 nematodes per pint of soil in the no-tillage to 1178 in the conventional tillage systems (P=0.0064). In regards to populations at 1st square, there were no significant main effect treatments of tillage, nematicide, or seed treatment. There was a significant two-way interaction between tillage and nematicide, while there were no differences among seed treatments (Table 1). It is common to see treated populations rebound throughout the growing season to a similar level comparable to the untreated. There were no differences between nematicide in the no-tillage, however, in the presence of nematode control in conventional tillage, populations were reduced. The understanding of tillage practices on nematode management is limiting, and there are positive benefits to both conventional and conservational tillage systems. Ultimately, the goal with tillage practice is to aid in minimizing plant stress and optimize plant growth (Minton, 1986).

The main effect treatment of nematicide had no differences on the number of thrips per five plants, or on plant vigor at the 3-4 leaf stage. At the 3-4 leaf stage, both immature and adult thrips were reduced with the no-tillage systems, numerous studies support the implementation of no-tillage for reducing thrips damage (Table 2). When evaluating at-planting treatments at the same time interval, immature thrips populations were significantly reduced by aldicarb followed by acephate plus terbufos compared to all other seed treatments, while acephate plus terbufos followed by aldicarb provided the greatest level of control of adults (Table 2). For both immature and thrips control, there was no difference between the thiamethoxam seed treatment and the untreated control.

All three main effect treatments were significant for thrips damage at the 3-4 leaf stage, while only tillage and at-planting treatment were for plant vigor (Table 3). With reduced thrips populations in the no-tillage systems, there was also a reduction in the amount of injury sustained and a reduced in plant vigor. Aldicarb followed by acephate plus terbufos provided the greatest amount of protection against thrips, as well as, had the greatest amount of plant vigor (Table 3). There were no difference in damage or vigor between thiamethoxam and the untreated control (Table 3). All three main effects of tillage, nematicide, and at-planting treatment had significant differences in the total dry plant biomass per five plants (Table 4). The highest plant biomass was associated with conventional tillage treatment over the no-tillage; 1, 3-dichloropropene compared to the no nematicide; and both aldicarb and acephate plus terbufos compared to all other at-planting treatments. While there were indications of early-season plant response in regard to tillage and seed treatment there were no differences in cotton yield (Table 4). However, the nematicide main effect is significant and treatments in the absence of a nematicide yielded higher (Table 4). The likely increase in yield in the absence of nematode control is due to the cotton plants recoverability for early-season stresses. The degree of recovery is dependent on a number of factors, such as environmental conditions or the time and severity of the injury (Cox et al., 1990; Hearn and Rosa, 1984; Sadras, 1995). Over the course of this study, optimal environmental conditions aided the plants ability to compensate from both early-season thrips and nematode stress. There were early season plant response to the use of tillage, nematicide, and seed treatment, however, they did correlate into difference in cotton yield.

Summary

The main strategy in early season pest management is to target early season plant growth and development to help combat other biotic and abiotic stresses throughout the season. It is important when considering the limited chemical options for both thrips and nematode management, to evaluate other cultural practices such as tillage and the influence it might have on minimizing stress to promote plant growth. In this study, both tillage systems had positive and negative attributes, depending on the production system would determine which tillage practice may be more beneficial. While nematicides provide effective control in suppressing nematode populations, the use of nematicides in Mississippi cotton production systems may be used situationally based on production history, the average amount of yield losses associated with reniform nematodes, and economics. In regards to thrips management, seed treatments and in-furrow applications have been and will continue to be one of the best management practices for control. Further research is needed to determine the relationship between tobacco thrips and reniform nematodes, and other stresses impacting their relationship.

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