NOTE

Attempts to Suppress Tomato Spotted Wilt Virus Using Selected Early-Season Thrips Control Tactics in Flue-Cured Tobacco[1]

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Tomato spotted wilt virus (TSWV) of the genus *Tospovirus* (Family: Bunyaviridae) causes economic losses to a range of crops worldwide (German et al. 1992, Ann. Rev. Phytopath. 30:315-348). TSWV is transmitted by thrips (Thysanoptera: Thripidae) (Ullman et. al. 1997, Pp. 539-565, Thrips as crop pests) and by mechanical means (Kumar et al. 1993, Plant Disease 77:938-941). Forty-three thrips species have been identified from tobacco foliage and blooms (McPherson et al. 1992, J. Entomol. Sci. 27:257-268). Most occur at very low densities and are not considered economically important, but *Frankliniella fusca* (Hinds), *F. occidentalis* (Pergande), *Haplothrips graminis* Hood, and *Chirothrins* spp. have been confirmed as potential vectors of TSWV in the tobacco farmscape (McPherson et al. 2003, J. Entomol. Sci. 38:660-668).

One promising control tactic is the use of the plant activator acibenzolar-S-methyl (Actigard 50 WG, Syngenta, Greensboro, NC) in combination with selected insecticides, including imidacloprid (Admire 2F, Bayer Agrichemical Division, Kansas City, MO) (McPherson et al. 1999, Plant Disease 83:765-767; 2003, J. Agric. Urban Entomol. 20:11-23; Pappu et al. 2000, Crop Protection 19:349-354; Csinos et al. 2001, Plant Disease 85:292-296). Actigard belongs to the chemical class known as benzothiodiazole, and exhibits a unique mode of action that mimics the natural systemic activated resistance response found in most plants (Novartis 1999, Actigard Tech. Bull. 4 Pp.) The study reported herein was conducted to examine the impacts of several early-season thrips control options, with and without the plant activator, on thrips population suppression and TSWV infection severity in tobacco.

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Tests were conducted at the McMillan Farm in Berrien Co., GA, during the 2000-2002 growing seasons. Cultivar K-326 flue-cured tobacco was transplanted on 13 April 2000, 6 April 2001 and 27 March 2002. Five days prior to transplanting, one-half of the transplants were treated with a tray drench application of Actigard at a rate of 2 g AI per 7000 transplants (0.0049 kg AI/ha); and the other half remained untreated. At transplanting, plots 8 rows wide (112-cm row spacing) by 106-m long were arranged in a randomized split-plot design with 4 replications. The main plots were transplants either treated or not treated with Actigard (4 rows). Sub-plots (4 rows × 21.2 m) within each main plot included foliar applications of five insecticide treatments: Actigard (0.03 kg AI/ha), acephate (Orthene 97 PE, Valent Corp., Walnut Creek, CA; 0.84 kg AI/ha), Actigard plus acephate (same rates), Spinosad (Tracer 4SC, Dow AgroSciences, Indianapolis, IN; 0.10 kg AI/ha), and no insecticide. The foliar sprays were applied immediately after transplanting and at 7, 17, and 27 d after transplanting using a tractor mounted sprayer delivering 38-L per ha at 276 KPa through a single TX-8 nozzle per row.

All plots were sampled weekly for adults thrips beginning soon after transplanting and continuing until the plants were topped (apical bud removed) and a sucker control agent applied (contact fatty alcohol that kills new growth on the main stem). All foliage on plant number 12, 14, 16 and 18 (middle of the plot) on row 2 of each plot was examined for the presence of thrips on each sampling date. On 5 sampling dates during mid-April to mid-May, when thrips population densities exceeded 1 per plant, thrips were randomly collected throughout the plots and placed in vials containing phosphate-buffered saline with 2% polyvinyl pyrrolidone and 0.02% sodium azide, returned to the laboratory, identified, then individually assayed by enzyme-linked immunsorbent assay (ELISA) for the presence of the nonstructural TSWV protein (NSs) encoded by the SRNA (Bandla et al. 1994, Phytopath. 84:1427-1431). A positive response indicated that TSWV has replicated in the thrips. A positive threshold in the ELISA was established at 2× higher than the negative control value plus the substrate had to turn yellow. At the time of crop topping, a random sample of thrips collected from the blooms also was placed in buffer, returned to the lab and assayed with ELISA as described for the foliage thrips collections.

All plants in each plot were visually examined weekly for symptoms of spotted wilt. Symptomatic plants were flagged and dated, and the cumulative percentage of infected plants was determined. Random symptomatic plants were confirmed TSWV positive using an ELISA commercially available kit (Agdia Incorp., Elkart, IN). Plant height, mean distance to the top of the highest uncurled leaf from 12 plants on rows 2 and 3 of each plot, was also measured in late-May or early-June. In late-June, the harvestable leaves on plants number 12-21 on the second and third rows of each plot were harvested and green weights determined. Green weights were converted to cured weights by multiplying by the factor of 0.15. PROC GLM was used in the analysis of thrips numbers by date and overall (mid-April through mid-May when thrips numbers were abundant), TSWV, plant height, and yield ($P = 0.05$; SAS Institute 1990). Treatment means were separated using the Tukey's lsd. The percentage of TSWV symptomatic plants was arcsine-transformed before analysis. Specimens of thrips reported in this study are located in the insect collection maintained at the Coastal Plain Experiment Station, Tifton, GA.

As would normally be expected in a field trial, the seasonal mean thrips populations varied greatly from year to year during this 3-yr study (Table 1). In 2000, the average population density for the 5-wk period when thrips were observed on the

Table 1. Seasonal mean population density of foliage thrips on flue-cured tobacco treated with selected foliar insecticides either with or without a tray drench application of Actigard, Berrien Co., GA, 2000-2002.

Treatment and kg AI/ha*	Mean thrips per four plants**		
	2000	2001	2002
	Spray treatment effects		
Actigard 0.03	3.7 ± 3.1a	18.5 ± 6.6ab	20.9 ± 10.5a
Acephate 0.84	3.4 ± 2.9a	10.8 ± 3.2c	22.8 ± 9.8a
Actigard + Acephate (same rates as above)	4.0 ± 3.9a	14.2 ± 3.9bc	20.2 ± 10.5a
Spinosad 0.1	3.5 ± 4.1a	22.0 ± 7.8a	21.7 ± 11.3a
Untreated	3.3 ± 3.0a	13.5 ± 4.0bc	22.6 ± 10.0a
	Tray drench effects		
Actigard TD 0.0049	3.2 ± 3.2a	16.4 ± 4.7a	23.9 ± 12.8a
No Actigard TD	4.0 ± 3.7a	14.6 ± 4.4a	19.4 ± 12.0a

* Foliar treatment applied at transplanting and 7, 17, and 27 days after transplanting. Tray drench treatment of Actigard applied five days before transplanting.

** Column means for each effect followed by the same letter are not significantly different (Tukey test, $P = 0.05$).

foliage (17 April-18 May) was no higher than 4 thrips per 4 plants on any of the treatments, including the untreated control. Thrips populations were almost nonexistent in April (ranging from 0.1 to 0.4 per 4 plants) and peaked on 3 May at between 2.6 and 5.8 per 4 plants. With these low population levels, spray treatment effects and drench treatment effects were not significant. In 2001, thrips densities were much higher. There were foliar spray treatment effects in the seasonal mean (27 April-25 May) thrips populations ($F = 4.77$; df = 4, 108; $P < 0.01$), with higher mean thrips in the Spinosad plots (Table 1). Thrips were very low in all plots in late April and peaked on 18 May with 77 thrips per 4 plants in the Spinosad plots to 37 thrips per 4 plants in the acephate plots. There was no Actigard tray drench effect on thrips populations in 2001 on any sampling date. In 2002, the seasonal mean thrips population densities were slightly higher than in 2001; however, there were no foliar spray treatment effects or tray drench effects. Thrips populations peaked on 9 May (50 per 4 plants in the control plots), and rapidly declined by 16 May (3.8 in the control plots). From the 500 or more foliage thrips tested with ELISA each season, 0.8, 7.8, and 5.6% were confirmed as positive for the nonstructural TSWV NSs protein in 2000, 2001 and 2002, respectively. Also 0.5, 5.6 and 1.1% tested positive (ELISA) from the 200+ thrips collected from tobacco blooms at this test site in 2000, 2001 and 2002, respectively.

There was less incidence of TSWV in the tray drench treatment with Actigard in both 2000 (a light infection year; $F = 4.22$; df = 1,27; $P = 0.05$) and 2002 (a severe infection year; $F = 7.75$; df = 1,27; $P < 0.01$) (Table 2). However, in 2001 there was

Table 2. Cumulative percentage of tomato spotted wilt virus symptomatic plants in flue-cured tobacco treated with selected foliar insecticides either with or without a tray drench application of Actigard, Berrien Co., GA, 2000-2002.

Treatment and kg AI/ha*	Cumulative % TSWV**		
	2000	2001	2002
	Spray treatment effects		
Actigard 0.03	9.1 ± 4.7a	21.3 ± 4.7a	50.0 ± 4.5ab
Acephate 0.84	12.9 ± 5.8a	24.3 ± 4.0a	47.5 ± 3.3b
Actigard + Acephate (same rates as above)	9.6 ± 4.8a	22.0 ± 3.9a	46.1 ± 3.8b
Spinosad 0.1	12.1 ± 5.9a	25.1 ± 6.6a	54.2 ± 4.0ab
Untreated	12.4 ± 6.0a	26.7 ± 6.1a	59.4 ± 4.9a
	Tray drench effects		
Actigard TD 0.0049	7.3 ± 2.6b	22.9 ± 6.1a	46.3 ± 4.0b
No Actigard TD	15.1 ± 4.6a	24.8 ± 4.9a	56.6 ± 5.1a

* Foliar treatment applied at transplanting and 7, 17, and 27 days after transplanting. Tray drench treatment of Actigard applied five days before transplanting.

** Column means for each effect followed by the same letter are not significantly different (Tukey test, $P = 0.05$).

no tray drench effect on TSWV. The foliar spray treatments had less incidence of TSWV only in 2002, the year with severe infection ($F = 5.23$; df = 4,27; $P < 0.01$). Under this heavy TSWV pressure, the incidence of TSWV was significantly below the untreated control with both the foliar sprays of acephate and acephate + Actigard.

Plant height was not affected by the foliar sprays on any year. In early season, there were some reductions in plant height and visual plant injury (stunting and discoloration) of all plants receiving the tray drench treatment each year. However, these plants had outgrown these effects by early June in 2000 and 2001, when the final plant heights were measured. Tobacco yields were affected by foliar spray and tray drench treatments in 2002, the year with the highest incidence of TSWV. The foliar Actigard + acephate treatment and the foliar acephate only treatment had significantly higher yields than the untreated control ($F = 3.09$; df = 4,27; $P = 0.04$). The plots treated with Actigard as a tray drench also had higher yields than the plots receiving no tray drench in 2002 ($F = 6.80$; df = 1,27; $P = 0.02$).

Previous studies (McPherson et al. 2002, 2003a) have reported that certain tray drench and foliar insecticide treatments can protect flue-cured tobacco from TSWV infection and yield losses associated with TSWV. Most foliar treatments in these earlier studies were not effective in suppressing TSWV. Results from data reported herein also demonstrate that intensive early-season foliar applications of selected pesticides (at transplanting and 7, 17 and 27 d after transplanting) did not suppress TSWV symptomatic plants.

The tobacco thrips, *F. fusca,* was the most abundant foliage thrips collected on tobacco on all 3 yrs of this study, comprising over 90% of the foliage thrips complex each year. This thrips species is reported as a vector of TSWV. In addition, the thrips species collected from tobacco blooms included the reported vector species *F. occidentalis.* Thus, thrips vectors are present in Georgia tobacco during April and May on foliage (*F. fusca*) and June-July on blooms (*F. occidentalis*). A tray drench treatment of Actigard will help to suppress TSWV symptoms and protect yield losses. In years when TSWV is severe (50%+), it appears that early-season foliar applications of acephate and acephate + Actigard can also be utilized to help suppress severity of TSWV infection and yield losses.

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