Management of TSWV on tomatoes with UV-reflective mulch and acibenzolar-S-methyl

M. T. Momol, J.E. Funderburk, S. Olson and J. Stavisky
University of Florida, IFAS, North Florida Research and Education Center, 30 Research Road, Quincy, FL 32351, USA.
E-mail: tmomol@GNV.IFAS.UFL.EDU

Abstract: Tomato spotted wilt virus vectored by western flower thrips (*Frankliniella occidentalis*) is the key disease of tomato in northern Florida and southern Georgia. Insecticides applied on a calendar schedule for thrips vector control are not effective in preventing disease. The insecticides are costly, toxic to farm workers, and disruptive to integrated pest management programs. We determined the separate and combined effects of a reduced-risk insecticide (spinosad), a systemic acquired resistance inducer (Actigard), and UV-reflective metalized mulch on management of tomato spotted wilt virus. The metalized mulch was most effective in reducing disease incidence. Actigard reduced incidence of tomato spotted wilt virus on the standard black mulch but not on metallized mulch. Spinosad was as effective as methamidophos in reducing the spread of the disease during mid- and late-season. The regimen of metalized mulch, Actigard, and insecticides reduced tomato spotted wilt virus by as much as 76%.

Introduction

Tomato spotted wilt virus (TSWV) is the type species of the genus *Tospovirus* in the family Bunyaviridae. Over the past two decades, increased outbreaks of TSWV occurred in a vast number of crops. The disease was originally described in Australia (Brittlebank 1919), with its etiology recognized by Samuel et al. (1930). These differ in serology, genome sequence, vector specificity, and natural host range. Thrips and TSWV are still considered new, emerging problems on agricultural crops in the southern US, even though growers in Georgia and northern Florida identified thrips and TSWV as their most serious insect and disease problems in a recent survey (Bauske et al. 1998). The growers further revealed that they apply on average 12.3 and 16.4 insecticides per season in Georgia and Florida, respectively. The conventional insecticide program for thrips consists of broad-spectrum insecticides (namely methamidophos). No single control measure has been reported as effective in reducing TSWV incidence.

TSWV is known to infect over 1,000 plant species in 80 botanical families. On tomato symptoms vary greatly, young leaves usually develop numerous small dark spots. Growing tips may dieback and streaks appear on terminal stems. Early infections cause severe stunting and severe reductions of fruit production. Plants infected after fruit-set produce fruit with chlorotic or necrotic ring spots. Green fruit with such spots will ripen with yellow blotches or spots.

Eight species in two thrips genera, *Frankliniella* and *Thrips*, are reported to transmit TSWV (Mound 1996, Webb et al. 1998). In Florida, the two main vectors are western flower thrips (*Frankliniella occidentalis*) and tobacco thrips (*F. fusca*). TSWV replicates in thrips vectors, thus the insect not only spreads the virus, but serves as a virus host. The virus is acquired by the larvae but not by the adults, and the adults can spread the virus to healthy host plants. The adults that successfully acquire the virus as larvae are responsible for transmission and spread. The adults persistently transmit TSWV and their control with insecticides does not prevent successful transmission due to the short time of feeding necessary for infection to occur (Nagata 1999).

Individual growers in the southern US typically have responded to the threat of TSWV by applying broad-spectrum insecticides on a calendar basis (e.g, Bauske et al. 1998). This approach is costly, highly toxic to farm workers, and extremely disruptive to IPM programs. Research has revealed consistently that losses to solanaceous crops from TSWV in the southern US are typically the result of primary infection that cannot be prevented by insecticide use (e.g., Puche *et al*. 1995, McPherson *et al*. 1995, 1997). This is because the disease is transmitted to plants before the thrips are killed by insecticides. However, control of larval thrips feeding on infected plants can prevent secondary spread that would occur when these thrips develop to adult. Few insecticides are efficacious against thrips, and some of these are carbamate and organophosphate insecticides that may not be available in the near future due to the Food Quality Protection Act.

Because insecticides do not prevent adult thrips that acquire disease from infected plants outside a tomato field from transmitting disease after migrating into the field, we have been investigating other management tactics. Highly UV-reflective aluminum (metalized) mulch is effective in reducing primary infections of TSWV. We showed during five years of research (1996-2000) that using metalized mulch reduces thrips populations and subsequent virus incidence about one half to two thirds in replicated field experiments (J. Funderburk, S. Olson, J. Stavisky and T. Momol, unpublished data). Better results were obtained in commercial tomato fields during the springs of 1999 and 2000.

Plants can activate protective mechanisms upon detection of invading pathogens. Protection expressed locally at the site of primary inoculation and also systemically in tissues remote from the initial treatment is known as systemic acquired resistance (SAR) (Sticher et al. 1997). Acibenzolar-S-methyl (Actigard), developed and marketed by Syngenta (Greensboro, NC), has been registered commercially in some countries as an inducer of SAR against a broad range of pathogens (Gorlach et al. 1996). The SAR inducer, Actigard has been effective in reducing incidence of TSWV on tobacco, especially in combination with insecticide imidacloprid (Pappu *et al*. 2000).

No single management tactic is highly effective in reducing losses from thrips and TSWV. Resistant varieties offer the best promise for reducing losses, but an integrated approach will still be necessary to reduce damage from thrips and to prevent development of TSWV strains able to infect resistant tomato cultivars (as happened in Hawaii).

The objective of this study was to determine the separate and combined effects of reduced-risk insecticides, a systemic acquired resistance inducer (Actigard), and metalized mulches on primary and secondary spread of tomato spotted wilt virus in tomato.

Materials and Methods

A randomized complete block experiment with four replications was conducted in the spring of 2000. The same experiment was conducted in 2001 with six replicates. The tomato crop was produced using typical commercial practices. A split-split-plot treatment arrangement was used to determine the separate and combined effects of each tactic on efficacy to reduce TSWV incidence. Tomato cultivar was 'FL 47'. Six-week-old transplants were spaced every 50 cm in raised beds covered with plastic mulch. Plants were irrigated based on plant needs through a trickle tube placed at the center of each bed. Treatment arrangement was a split-split plot with mulch type the whole plot treatments, Actigard/no Actigard as the split plot treatments (16 replicates) and insecticide treatments (4 replicates) the split-split plot. Mulch type was selected as the whole plot because the mulch type can affect thrips on adjacent rows. Interplot interference was detected in the experiment conducted in 1999, therefore the whole plots in 2000 were separated by a 2 m buffer zone. The standard mulch type was black and the other type was metallized mulch. The Acibenzolar-S-methyl (Actigard) treatment was a regimen of applications: 2 g [AI]/4000 plants washed in 1 week prior to transplanting and 26.25 g [AI]/ha four foliar sprays applied every fifteen days after transplanting. Insecticide treatments for thrips were untreated, spinosad (0.07 kg[AI]/ha), and methamidophos (0.4 kg [AI]/ha) and a combination of spinosad with methamidophos. These were applied weekly for six weeks from late April to early June.

Plot size for each split-split plot was 4 rows by 11 m. Parameters evaluated included % infected plants (tomato spotted wilt incidence), thrips per flower, and fruit yield and quality. Incidence of tomato spotted wilt in each plot was determined by % plants with visible symptoms weekly or bi-weekly from May 2nd to June 21st. Symptomatic plants were tested for each sampling date by ELISA (Agdia, Elkhart, IN) in order to confirm a diagnosis of TSWV. Thrips were sampled 2 and 6 days after each weekly application of insecticides. On each sample date, ten flowers from each sub-subplot were placed in 70% alcohol and carried to the laboratory. Thrips adults were extracted and identified to species under a 40X dissecting microscope, and thrips larvae were quantified.

Results and Discussion

In the spring of 2000, North Florida experienced a severe epidemic of TSWV on tomatoes. In 2001 tomato spotted wilt incidences were not high. In this experiment infections occurred naturally. Thrips common in the tomato flowers both years were *F. occidentalis, F. tritici and F. bispinosa*. Incidence of *F. occidentalis* in 2000 is shown in Figure 1.

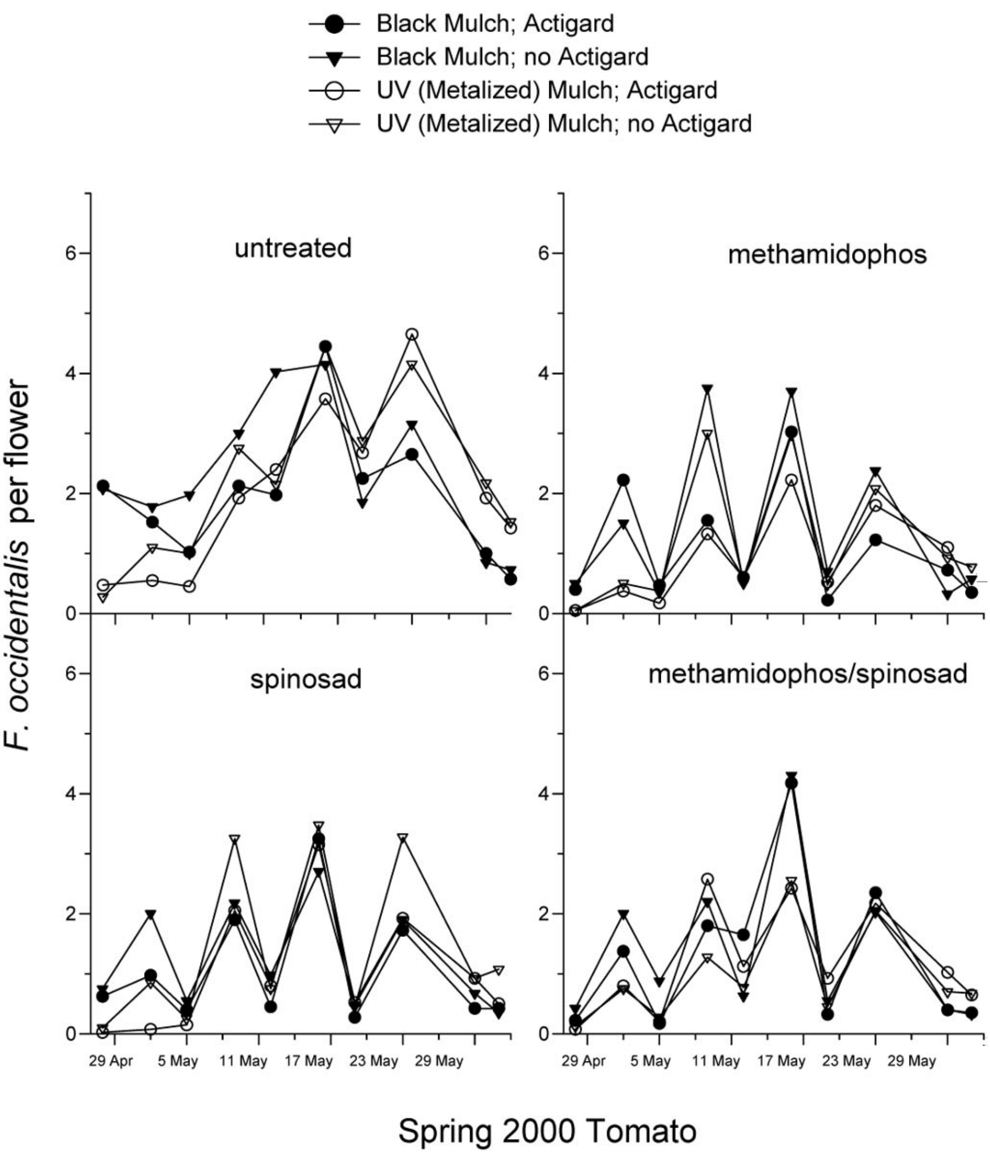

Figure 1. Mean number of *F. occidentalis* in tomato flowers in April and May 2000.

		% Incidence of Tomato spotted wilt (Final Disease)			
Mulch Type	**Insecticide**^{z}	**Actigard**		**No Actigard**	
Black	UTC	33.3^{y}	28.7^{x}	46.3	38.1
	Mon	28.6		38.2	
	Spin	29.8		34.9	
	Mon + Spin	23.0		33.0	
UV-Reflective (Metalized)	UTC	23.8	17.3	22.5	19.7
	Mon	11.4		16.2	
	Spin	17.1		24.1	
	Mon+Spin	16.9		16.0	

^{z} Insecticide, UTC = Untreated control, Mon = Monitor (methamidophos), Spin = Spin Tor (Spinosad), Mon+Spin (Monitor and Spin Tor weekly alternated).
^{y} % Incidence is average of 4 replicates
^{x} % Incidence is average of 16 replicates

Table 1. Effect of mulch type, Actigard and insecticides on the incidence of tomato spotted wilt in tomato (Spring 2000).

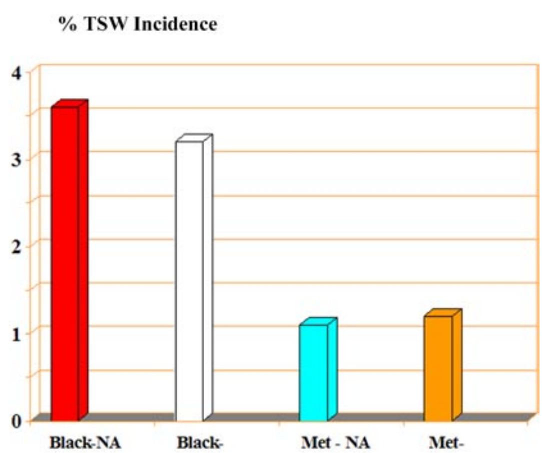

Figure 2. Effect of mulch type (Black vs. Metalized), Actigard (AT) and no-Actigard (NA) on the incidence of tomato spotted wilt (TSW) in tomato (Spring 2001, as of June 5).

The overall incidence of TSWV was significantly lower in metallized mulch plots than the black mulch plots (Table 1 and Fig. 2). Applications of Actigard did not decrease disease incidence in metallized mulch treatments. Actigard was effective in reducing disease incidence on black mulch. Numbers of larval thrips per flower were decreased by each insecticide treatment (Fig. 3), which reduced the amount of secondary disease incidence that occurred primarily in mid- to late-season. The regimen of metallized mulch, Actigard, and insecticides reduced TSWV compared to incidence on untreated black mulch by as much as 76%.

Our research has demonstrated that metallized mulch is an effective tactic to reduce thrips populations and resulting infection by TSWV. This tactic serves to reduce both primary and secondary infection. Secondary infection can occur if thrips larvae are not controlled by insecticides. Methamidophos is efficacious against thrips, and spinosad is a safer, biological insecticide with efficacy against *F. occidentalis* adults and larvae. Actigard needs further evaluation, but shows promise as a management tactic against TSWV.

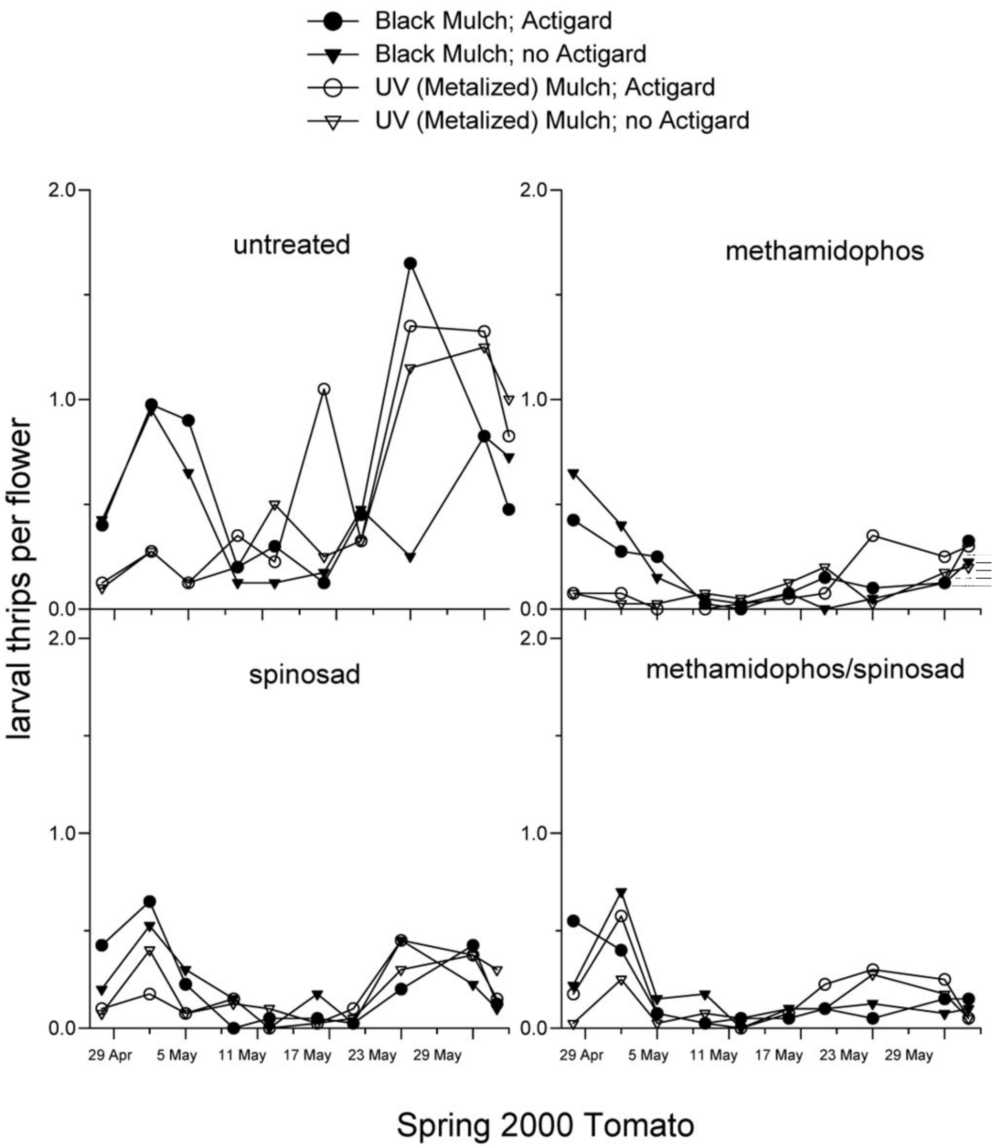

Figure 3. Mean number of larval thrips in tomato flowers in April and May 2000.

Acknowledgements

We thank Paula Bernsen, Jackie Snell, and Hank Dankers for technical assistance.

References

Bauske EM, Zehnder GM, Sikora EJ and Kemble J. 1998. Southeastern tomato growers adopt integrated pest management. *HortTechnology* **8**, 40-44.

Brittlebank CC. 1919. Tomato diseases. *J. Agric. Victoria* **27**, 213-235.

Gorlach J, Volrath S, Knauf-Beither G, Hengy G, Beckhove U, Kogel K-H, Oostendorp M, Staub T, Ward E, Kessman H and Ryals R. 1996. Benzothiadiazole, a novel class of inducers of systemic acquired resistance, activates gene expression and disease resistance in wheat. *The Plant Cell* **8**, 629-643.

McPherson RM, Culbreath AK, Stephenson MG and Jones DC. 1995. Impact of transplant date and insecticide control practices on the incidence of tomato spotted wilt virus and insect pests of flue-cured tobacco. *Tobacco Sci*. **39**, 30-37.

McPherson RM, Pappu HR, Csinos AS and Bertrand PF. 1997. Influence of dichloropropene, volunteer peanuts, and thrips control practices on the abundance of insect pests and incidence of tomato spotted wilt in flue-cured tobacco. *Tobacco Sci*. **41**, 94-102.

Mound LA. 1996. The Thysanoptera vector species of Tospovirus. *Acta Hort*. **431**, 298-307.

Nagata T. 1999. Competence and specificity of thrips in the transmission of tomato spotted wilt virus. Thesis Wageningen, 96pp.

Pappu HR, Csinos AS, McPherson RM, Jones DC and Stephenson MG. 2000. Effect of acibenzolar-S-methyl and imidacloprid on suppression of tomato spotted wilt *Tospovirus* in flue-cured tobacco. *Crop Protection* **19**, 349-354.

Puche H, Berger RD and Funderburk JE. 1995. Population dynamics of *Frankliniella thrips* and progress of tomato spotted wilt virus. *Crop Protection* **14**, 577-583.

Samuel G, Bald JG and Pitman HA. 1930. Investigations on 'spotted wilt' of tomatoes. Commonwealth *of Australia, Council Sci. Ind. Res. Bull*. **44**, 64.

Sticher L, Mauch-Mani B and Metraux JP. 1997. Systemic acquired resistance. *Annu. Rev. Phytopathology* **35**, 235-270.

Webb S, Tsai J and Mitchell F. 1998. Bionomics of *Frankliniella bispinosa* and its transmission of tomato spotted wilt virus. pp. 67-68 in *The Fourth International Symposium on Tospovirus and Thrips in Floral and Vegetable Crops*. Wageningen, The Netherlands.