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Research Update on Tomato Chlorotic Spot Tospovirus in South Florida from 2017 to 2018

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During the 2017 and 2018 tomato growing seasons, field experiments were conducted to evaluate the efficacy of strategies on tomato chlorotic spot tospovirus (TCSV) management in south Florida. Strategies included using UV-reflective plastic to repel thrips and the application of a systemic acquired resistance (SAR) elicitor to induce plant resistance. A survey was conducted in a heavily TCSV-infested commercial field in 2018 to determine the distribution pattern of TCSV-affected plants. TCSV incidence was very low in trials at TREC in both growing seasons, though low populations of two types of thrips were found present in tomato flowers in the field. Therefore, no conclusions could be made regarding the efficacy of the two treatments on TCSV. Actigard™ did not significantly affect tomato yield, while metalized plastic mulch was able to enhance yield at early harvest compared to the commonly used black mulch. Survey data indicated that viruliferous thrips were from a source outside the field. The population was large, but resistant cultivars were available and highly effective in controlling TCSV.

Tomato (*Solanum lycopersicum* L.) is the most economically important vegetable crop in Florida where approximately 36% of the U.S. fresh market tomatoes are produced (Florida Dept. of Agriculture and Consumer Services, www.freshfromflorida.com). Many viruses infect tomato plants in south Florida, including tospoviruses such as tomato spotted wilt tospovirus (TSWV) and groundnut ringspot tospovirus (GRSV) (Webster et al., 2010; Zitter, 1981), causing serious losses to tomato growers in this region. Although tomato chlorotic spot tospovirus (TCSV) was first detected on tomato in south Florida in 2012 (Londoño et al., 2012), TCSV has become the most dominant tospovirus in the area since 2014 (Zhang et al., 2015b). TCSV, GRSV, and TSWV have been found sympatrically in south Florida. GRSV and TCSV have been detected from the same host plant (Webster et al., 2015).

Like other tospoviruses, TCSV is transmitted by western flower thrips (*Frankliniella Occidentalis*) and common blossom thrips (*F. schultzei*) in a persistent manner (Webster et al., 2015). The virus is acquired by J2 thrips and also appears in viruliferous adults. In tomato plants, infection with TCSV incites symptoms including systemic necrosis on leaves and stems, leaf distortion, deformation of leaflets, necrotic ring spots on tomato fruit, and finally death of the top portion of the plant. In late stage of infection, dark and bronze ring spots can be seen on infected leaves (Londono et al., 2012). When plants are infected at an early stage, the growth of the plant can be heavily stunted. Based on field observations, symptoms of TCSV develop and expand more rapidly than TSWV and GRSV in south Florida. Leaf tissues can be dry within 3–5 days of the infection first being observed.

Since the 2014–15 tomato growing season, widespread symptoms of TCSV have been observed in Homestead, FL, where TCSV was first detected in tomato plants in 2012 (Londono et al., 2012). Approximately 30 to 40% of tomato plants show symptoms in commercial fields. Growers must rogue infected plants hoping to reduce further infection (Zhang et al., 2015b). Because TCSV is a new disease in the United States, there are no proven effective management practices available for tomato growers. Current recommended strategies are based on those for the genetically similar TSWV, including use of resistant cultivars, use of UV-reflective plastic mulch, pesticides to manage thrips populations, and the application of systemic acquired resistance (SAR) elicitors, such as acibenzolar-S-methyl (ASM, Actigard™, Syngenta, Greensboro, NC). Apparently, understanding the epidemiology of the disease will facilitate the development of management strategies for this important disease. We tried to evaluate control strategies for TCSV in south Florida using UV-reflective plastic mulch and the application of the plant activator Actigard. In addition, we conducted a survey in a heavily infested tomato field in the spring of 2018 to determine the disease pattern in the field. This may help elucidate the epidemiology of the virus.

Materials and Methods

Effects of UV-reflective plastic mulch and Actigard on thrips population, TCSV incidence and tomato yield. The experiment was conducted at the University of Florida, Institute of Food and Agricultural Sciences (UF/IFAS) Tropical Research and Education Center (TREC) research farm in 2017 and 2018. Metalized plastic mulch and regular black mulch were used to prepare beds for transplanting tomato. The experiment

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Table 1. Thrips population (thrips adults/six flowers) in tomato flowers on UV-reflective and black plastic mulched beds.

		2017			2018			
Thrips	Plastic	27 Feb.	7 Mar.	14 Mar.	2 Mar.	8 Mar.	16 Mar.	27 Mar.
Western flower thrips	Metalized mulch	0.75	0.74	2.00	0.83	1.16	1.00	0.58
	Black mulch	1.90	0.25	1.24	1.17	0.74	0.66	1.5
Common blossom thrips	Metalized mulch	0.87	0.00	2.37	0.33	0.41	0.75	0.16
	Black mulch	1.25	0.00	1.74	1.07	0.16	0.58	0.83

was designed as a split-plot with plastic type as the main factor. Three beds of each type of plastic comprised a group. There was an 18-ft. driveway between the two types of beds. Each bed was 300 ft. long and 3-ft. wide. On each type of bed, plots were treated with or without Actigard™. There were four replications for each treatment and subplots were arranged randomly. Plants of 'Sanibel' were transplanted on 15 Dec. 2016 and seedlings of Florida 47' were transplanted on 22 Nov. 2017 in the 2017 and 2018 growing seasons, respectively. Fertilizer applications and pest management (other than thrips) were implemented for optimum crop production according to the 2016–17 Vegetable Production Handbook of Florida. Actigard™ was applied weekly at 0.33 ounces per acre (oz/A) for weeks 1 and 2 after transplanting; 0.5 oz/A for weeks 3 and 4 after transplanting; and 0.75 oz/A for weeks 5 to 8 after transplanting. After the eighth week, Actigard™ was applied every two weeks at a rate of 0.75 oz/A. Populations of western flower thrips and common blossom thrips were sampled three times on 27 Feb., 7 Mar., and 14 Mar. in 2017, and four times on 2 Mar., 8 Mar., 16 Mar., and 27 Mar. in 2018, respectively. At each sampling time, six flowers were collected randomly from each plot, placed in a zip-top plastic bag and stored in an air tight container, brought back to laboratory for thrips species identification following a standard procedure (Seal et al., 2014). TCSV incidence was recorded weekly for each plot after the first plant showing TCSV symptoms was found in the field.

Distribution of TCSV-affected plants in a commercial tomato field. In late February 2018, a severe infestation with tospoviruses was observed in a grower's tomato field (600 feet long) planted with 'Sanibel', 'Florida 47', 'Red Bounty', and 'Southern Ripe' in Homestead, FL. Based on the symptoms and RT-PCR test of samples with specific primers for TCSV, TCSV was the dominant (>95%) tospovirus in this field. Tomatoes were planted in beds with a south to north orientation. There were ornamental nurseries to the south side and a row of palm trees (40–50 f.t in height) planted along a road at south side crossing one section of the tomato field. To obtain information about the disease epidemiology, particularly the dispersal of the vectors, a survey was conducted in this particular field for distribution of the TCSV-affected plants in late March 2018. Four sections were surveyed. One section was at east of the palm trees where 'Red Bounty' was planted. Two sections were in the middle of the field where 'Sanibel' and 'Florida 47' were planted. Within these two sections, one sampled area was across the palm trees and the other sampled area was immediately west of palm trees. One section was at far west where 'Southern Ripe' was planted. In each section, the survey was conducted with two adjacent rows considered as one sample, and next sample was taken on two additional rows by skipping two rows between sample sites. Sampling always started from the southern edge of the field. In two adjacent rows, every 100 plants (about 100 ft in length, 50 plants in each row) were selected as a sampling unit and a total of six sampling units consisting 600 plants (about 600 ft in length) were surveyed in each field. A total of 3, 13, 8, and 3 samples were surveyed in each of the four sections in the field from east to west, respectively. The percentage of TCSV-affected tomato plants was calculated for each sampling unit, each sample, and each surveyed section.

Results and Discussion

Effects of UV-reflective plastic mulch and Actigard™ on thrips population, TCSV and tomato yield. In both years, low populations of both western flower thrips and common blossom thrips were found in tomato flowers in the trials conducted at TREC (Table 1). There was no clear trend regarding the thrips populations on the two different types of plastic. There were few incidences of TCSV in the field in both years. In 2018, there were only two infected shoots in the first row on the east side of the field near the end of the season. The reasons that incidence of TCSV was so low are unknown. It was not clear if low incidence of TCSV in the field was due to low vector populations, or the lack of viruliferous vectors. A reliable, sensitive, and fast technique that can recognize the presence of viruliferous vectors of TCSV from those that are TCSV-free in the air or on tomato plants could have enabled us to predict whether a potential disease outbreak could occur in the near future.

In both 2017 and 2018, the application of Actigard™ had no

Table 2. Effects of Actigard™ on tomato yield grown on two different plastics in south Florida.

		Plastic	
Growing season	Treatment	Metalized	Black
2017	Non-treated	4.41 a[z,y]	3.27 a
	Actigard	4.21 a	3.35 a
2018	Non-treated	4.16 a	3.48 a
	Actigard	3.82 a	3.25 a

[z]Tomato yield was total fruit (kg)/plant; tomato fruit were harvested two times in both years.

[y]Means were not significantly different at $P = 0.05$ if followed by same letter between two treatments in the same column for the same year.

Table 3. Effects of plastic mulch on tomato yield in south Florida

	2017		2018	
Tomato yield/plant (kg)	Metalized	Black	Metalized	Black
Extra large fruit—harvest 1	1.86 a[z]	1.35 b	1.40 a	0.99 b
Large fruit—harvest 1	0.91 a	0.52 b	0.66 a	0.48 b
Extra large fruit—harvest 2	0.61 a	0.49 a	0.99 a	0.99 a
Large fruit—harvest 2	0.76 a	0.74 a	0.91 a	0.98 a
Total yield	4.41 a	3.27 b	4.16 a	3.48 b

[z]Means were significantly different at $P = 0.05$ if followed by different letters between two plastic mulches in each year within the same row.

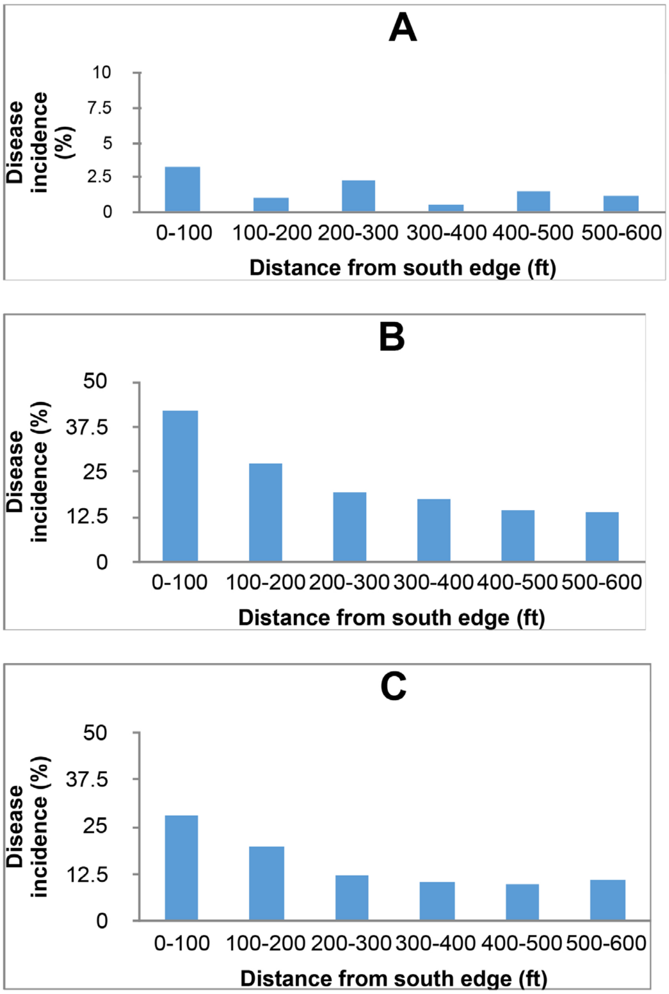

Fig. 1. Incidence of TCSV-affected plants in a commercial field of Miami-Dade County, FL in the spring of 2018. (**A**), section with cultivar 'Red Bounty' at east of palm trees; (**B**) section with cultivar 'Florida 47' right across palm trees; (**C**) section with cultivar 'Sanibel' immediately west of palm trees.

adverse effect on tomato yield in both types of plastic (Table 2). Such results indicate that Actigard™ may not affect tomato yield if it is applied appropriately. Tomato plants grown on metalized mulch produced significantly more extra large and large fruit in the first harvest than those grown on black mulch (Table 3). Though there was no significant effect on the yield at the second harvest, the total yield was higher for tomatoes grown on metalized mulch than on black plastic mulch. Our results with the effect of metalized mulch on tomato yield were similar to previous reports (Csizinszky et al., 1999). The beneficial effects of metalized mulch on tomato yield might be due to the fact that metalized mulch can help decrease extreme high temperatures during day time while maintaining soil temperature at night (Csizinszky et al., 1995; Ham et al., 1991). In addition, metalized mulch can help reduce incidence of tomato yellow leaf curl virus infections (Schuster et al., 2011).

Distribution of TCSV in a commercial tomato field. In the east section ('Red Bounty'), the average incidence of TCSV-affected plants was 1.6%, with an incidence of 3.3% in the first 100 ft and a lowest incidence of 0.5% (Fig. 1A). In the section ('FL 47') across from the palm trees, the average incidence of TCSV-affected plants was 22.4%, with an incidence of 42.2% in the first 100 ft. from the south side and a lowest incidence of 13.9% at 500–600 ft. from the south side (Fig. 1B). In the section ('Sanibel') immediately west of the palm trees, the average incidence of TCSV-affected plants was 15.1%, with an incidence of 28.0% in the first 100 feet and a lowest incidence of 9.8% (Fig 1C). In the far west section ('Southern Ripe'), the average incidence of TCSV-affected plants was 0.2%. An apparent trend was seen in the middle of two heavily infested sections where the incidence of TCSV-affected plants was the highest in the first sample unit at the south edge, and gradually decreased from south to north.

The distribution of TCSV-affected tomato plants in this commercial field indicated that a large population of viruliferous vectors likely came from an outside source, dispersed into the field at the south edge, and spread northward. As TCSV has been reported from an ornamental crop in a nursery in Miami-Dade County (Dey et al., 2017), it is possible that the vectors came from nurseries or the palm trees through wind. Further study is needed in order to determine a potential crop (likely ornamental crop in this case) that is host of TCSV which can support a large quantity of thrips. In addition, two tomato cultivars, 'Red Bounty' and 'Southern Ripe', were found to be highly resistant to TCSV. Resistant tomato cultivars can be the most powerful tool for managing this destructive disease among various TCSV management strategies. Since 2014, field trials have been conducted in Homestead, FL to evaluate resistance of tomato cultivars, especially those resistant to TSWV. It has been confirmed that TSWV resistant/tolerant tomato cultivars are also resistant/tolerant to TCSV under commercial production conditions of south Florida (Zhang et al., 2015a). Continuing work is still needed to evaluate more tomato cultivars and breeding lines for their resistance against TCSV so that they can be adopted by tomato growers for commercial production or used in breeding programs to develop more resistant cultivars.

Literature Cited

Csizinszky, A.A., D.J. Schuster, and J.E. Polston,. 1999. Effect of ultraviolet-reflective mulches on tomato yields and on the silverleaf whitefly. HortScience 34(5):911–914.

Csizinszky, A.A., D.J. Schuster, and J.B. Kring. 1995. Color mulches influence yield and insect pest populations in tomatoes. J. Amer. Soc. Hort. Sci. 120:78–784.

Dey, K., M. Melzer, X. Sun, and S.T. Adkins. 2017. *Tomato chlorotic spot virus* identified in *Marsdenia floribunda* in Florida. Plant Health Progress. 18:144–145. doi:10.1094/PHP-05-17-0030-BR.

Ham, J.M., G.J. Kluitenberg, and W.J. Lamont. 1991. Potential impact of plastic mulches on the aboveground plant environment. p. 63–69. Proc. Natl. Agr. Plastics Congr. Mobile, Al. 29 Sept.–3 Oct. 1991.

Londoño, A., H. Capobianco, S. Zhang, and J.E. Polston,. 2012. First record of tomato chlorotic spot virus in the USA. Tropical Plant Path. 37:333–337

Schuster, D.J., J.P. Gilreath, R. Cordero, and P.R. Gilreath,. 2011. Reduced incidence of tomato plants with symptoms of *tomato leaf yellow curl virus* infection grown on ultraviolet-reflective soil mulch. Proc. Fla. State Hort. Soc. 124:162–165.

Seal, D.R., V. Kumar and G. Kakkar. 2014. Common blossom thrips, *Frankliniella schultzei* (Thysanoptera: Thripidae) management and *Groundnut ring spot virus* prevention on tomato and pepper in south Florida. Florida Entomol. 97 (2):374–383.

Webster, C.G., K.L. Perry, X. Lu, L. Horsman, G. Frantz, C. Mellinger, and S. Adkins. 2010. First report of groundnut ringspot virus infecting tomato in south Florida. Online Plant Health Progress. doi:10.1094/PHP-2010-0707-01-BR.

Webster, C.G., G. Frantz, S.R. Reitz, J.E. Funderburk, H.C. Mellinger, E. McAvoy, W.W. Turecheck, S.H. Marshall, Y. Tantiwanich, M.T. McGrath, M.L. Daughtrey, and S. Adkins. 2015. Emergence of Groundnut ringspot virus and Tomato chlorotic spot virus in vegetables in Florida and Southeastern United States. Phytopathology. 105:388–398.

Zhang, S., D. Seal, Q. Wang, and E. McAvoy. 2015a. Evaluation of tomato cultivars and insecticides for management of *Tomato chlorotic spot virus* (TCSV) and thrips species recorded in virus-infected tomato fields. In: Ozores-Hampton, M. and Snodgrass, C. (eds.). Proceedings of Florida Tomato Institute. UF/IFAS. pp. 28–30.

Zhang, S., D.R. Seal, Q. Wang, E. McAvoy, E., and J.E. Polston. 2015b. An outbreak of *Tomato chlorotic spot virus*, an emerging tospovirus threatening tomato production in the United States. Phytopathology. 105 (Suppl. 4): S4.156.

Zitter, T.A. 1981. Viruses infecting tomato in Southern Florida. Plant Dis. 65:787–791.