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Reduced Incidence of Tomato Plants with Symptoms of *Tomato yellow leaf curl virus* Infection Grown on Ultraviolet-reflective Soil Mulch

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Biotype B of the sweet potato whitefly, *Bemisia tabaci* (Genn.) is a major economic pest of tomatoes, *Solanum lycopersicum* (L.) in southern Florida. Most economic damage occurs through the transmission of *Tomato yellow leaf curl virus* (TYLCV) on tomato. Ultraviolet light reflective (metalized) polyethylene mulch was evaluated as an alternative method to insecticides for managing whitefly adults and TYLCV. In studies conducted in the spring seasons of 2005 and 2006, whitefly adult abundance and incidence of plants with symptoms of TYLCV infection were compared for tomato plants grown on raised beds covered with a metalized mulch, a black mulch, or a white on black virtually impermeable film mulch. The numbers of whitefly adults did not always differ statistically on specific sampling dates on plants grown on the different mulches; however, the cumulative numbers of adults over sampling dates did. A lower percentage of tomato plants grown on metalized mulch had symptoms of TYLCV infection compared to tomato plants grown on black or white mulch film in 2005 and to plants grown on white mulch in 2006. Using metalized mulch can contribute to management of whitefly adults and TYLCV.

Biotype B of the sweetpotato whitefly, *Bemisia tabaci* (Genn.), also known as the silverleaf whitefly, *B. argentifolii* Bellows and Perring, is an important pest of many horticultural and agronomic crops worldwide (Perring et al., 1993) and is the most important insect pest of tomatoes, *Solanum lycopersicum* (L.), in peninsular Florida (Schuster et al., 1996a). Feeding by the pest, especially nymphs, can cause direct damage including leaf and fruit spotting, plant debilitation, sooty mold growth on honeydew and irregular ripening of fruit (Schuster et al., 1996b). The greatest economic threat is due to the ability of *B. tabaci* to transmit plant viruses, the most damaging of which on tomatoes in Florida is *Tomato yellow leaf curl virus* (TYLCV). Symptoms of TYLCV infection include curling, mottling and reduction of size of leaflets; chlorosis of the margins of leaflets; abscission of flowers; stunting of plants; and reduced yields (Mohamad, 2010; Polston et al., 1999). The earlier plants are infected, the greater the severity of symptoms and the subsequent negative impact on growth and yield (Saikia and Muniyappa, 1989). Even though all lifestages of *B. tabaci* occur on the undersides of leaves (Sharaf, 1986), growers routinely apply insecticides targeting *B. tabaci* adults in order to avoid losses due to TYLCV infection. While this tactic can have some success, the whitefly has developed resistance to every major class of insecticide (Horowitz et al., 2007; Palumbo et al., 2001; Schuster et al., 2010). Clearly, more sustainable approaches to management are desirable.

Yellow polyethylene film mulch covering the soil of plant beds has been shown to reduce the population of *B. tabaci* and the spread of TYLCV on tomato plants growing on the mulch in Israel (Cohen and Melamed-Madjar, 1978). Whitefly adults are attracted to yellow and presumably stayed long enough on the yellow mulch to be killed by heat (Cohen, 1982). In Jordan, a "silver" mulch resulted in 60% to 80% fewer tomato plants with symptoms of TYLCV infection compared to black or white mulches or to bare soil (Suwwan et al., 1988). No direct impacts on *B. tabaci* adults were reported. In Florida, ultraviolet light-reflective aluminum mulches resulted in reduced numbers of whitefly adults settling on tomato plants grown on the mulches (Csizinszky et al., 1995, 1997, 1999). The present studies were undertaken to evaluate the abundance of *B. tabaci* adults on tomato plants and the incidence of tomato plants with symptoms of TYLCV infection when the plants were grown on ultraviolet light-reflective aluminum polyethylene mulch in a commercial production setting.

Materials and Methods

Two experiments were conducted, one each in the spring seasons of 2005 and 2006, on a commercial tomato farm setting near Sun City, FL. In both experiments, each plot consisted of three, 100 ft long rows of raised Myakka fine sand spaced 5 ft apart and covered

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with polyethylene film mulch immediately after fumigation with methyl bromide. In 2005, the mulches included Hilex hdpe black (Hilex Poly Co., LLC, Hartsville, SC), IPM Bromostop® VIF white on black (Industria Plastica Monregalese, Mondovi, Italy) and Canslit full metalized aluminum (Canslit, Inc., Montreal, Quebec, Canada). In 2006, Bromostop "Shimmering" VIF white on black (Industria Plastica Monregalese, Mondovi, Italy) was substituted for the IPM Bromostop film. There were four replications in a randomized complete block experimental design. Transplants of tomato 'Fl 47' and 'Sunguard' were set 27 Jan. 2005 and 18 Feb. 2006, respectively, 2 ft apart. In 2006, plants were drenched at transplanting with thiamethoxam (Platinum 2SC, Syngenta Crop Protection, Greensboro, NC) at 8 oz/acre in 4 oz solution per plant. No other insecticide applications were made in either year, but foliar applications of fungicides and bactericides were made weekly in both years. The numbers of silverleaf whitefly adults were counted weekly on the top three leaves of two stems of each of 20 plants in the middle of the middle row of each plot. The numbers of plants (of 50) in the middle row of each plot with definite symptoms (curling, mottling and reduction of size of leaflets; chlorosis of the margins of leaflets) of TYLCV were recorded weekly. The area under the disease progress curve was calculated for each plot based upon the cumulative proportion of plants with symptoms of TYLCV infection, and the area under the progress curve was calculated for each plot based upon the cumulative numbers of whitefly adults. The values for the area under the disease progress curves and the area under the progress curves were determined by graphing the cumulative data, calculating the areas of the series of right triangles and rectangles of each of the graphs, and then totaling these areas for each graph. Data were subjected to analyses of variance using the general linear means model (PROC GLM of SAS, SAS Institute, 2002) and means were separated using Fisher's Protected LSD ($P = 0.05$).

Results and Discussion

The sweetpotato whitefly population was low during the 2005 trial. Significantly fewer adults were observed on plants growing on the Canslit metalized mulch compared to those growing on the either the Hilex black mulch or the IPM Bromostop white mulch 7 and 9 weeks after transplanting (Fig. 1). In contrast, the cumulative numbers of *B. tabaci* adults on plants grown on the metalized mulch were significantly less than those on plants grown on the black mulch on all sampling dates except the first (Fig. 2). In addition, 10, 11, 12, 13, and 14 weeks after transplanting, the cumulative numbers of adults on plants on the metalized mulch were lower than the numbers on plants on the white mulch film. The area under the progress curve for the cumulative number of adults on plants on the metalized mulch was significantly less than those for plants on the black or white films (Table 1). Tomato plants grown on the metalized mulch had a significantly lower cumulative percentage of plants with symptoms of TYLCV infection compared to plants grown on either the black or the white mulch on all sampling dates (Fig. 3). As with the cumulative number of adults, the area under the disease progress curve for the percentage of plants with symptoms of TYLCV infection was significantly less for plants grown on the metalized mulch than for plants grown on either the black or the white mulch (Table 1).

The *B. tabaci* population was much higher in 2006 than in 2005 (Fig. 4). Fewer adults were observed on plants grown on the Canslit metalized mulch compared to plants grown on the Hilex HDPE black mulch 5 and 7 weeks after transplanting

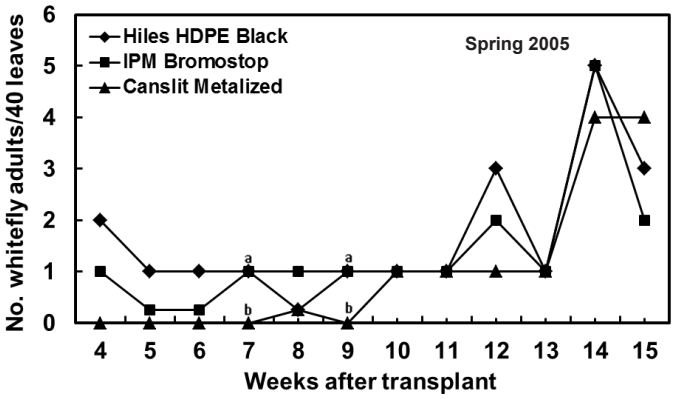

Fig. 1. The number of adult *Bemisia tabaci* observed on tomato plants grown on polyethylene soil mulches. Data points within a given week after transplanting with different letters are significantly different by Fisher's Protected LSD at P = 0.05. Data points with no letters are not significantly different.

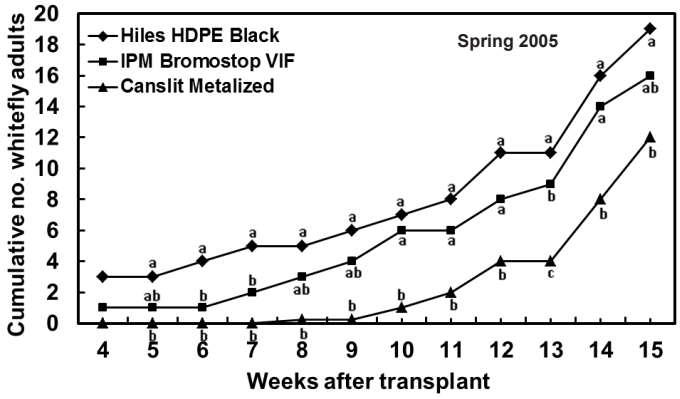

Fig. 2. The cumulative number of adult *Bemisia tabaci* observed on tomato plants grown on polyethylene soil mulches. Data points within a given week after transplanting with the same letter are not significantly different by Fisher's Protected LSD at $P = 0.05$. Data points with no letters are not significantly different.

(Fig. 4). The cumulative numbers of *B. tabaci* adults on plants grown on the metalized mulch were significantly less than those on plants grown on the black mulch on weeks 5 through 10 after transplanting (Fig. 5). In addition, on the sixth week after transplanting, the cumulative number of adults on plants on the metalized mulch was lower than the number on plants grown on the Bromostop "Shimmering" VIF white mulch. The area under the progress curve for the cumulative number of adults on plants on the metalized mulch was significantly lower than the number on the plants on the black mulch but not the white mulch (Table 1). Tomato plants grown on metalized mulch film had a lower cumulative percentage of plants with symptoms of TYLCV infection as compared to those grown on white film 6, 7, 10, and 12 weeks after transplanting (Fig. 6). The percentage was also less for plants grown on the black mulch 6 weeks after transplanting. The area under the disease progress curve for the percentage of plants with symptoms of TYLCV infection was significantly less for plants grown on metalized mulch than for plants grown on the white mulch but not for those on the black mulch (Table 1).

The numbers of whitefly adults did not always differ statistically on specific sampling dates on plants grown on the different

Table 1. Area under the progression curve and area under the disease progression curve for the cumulative number of *B. tabaci* adults and cumulative percentage of plants with symptoms of *Tomato yellow leaf curl virus* (TYLCV) infection, respectively.

	2005		2006	
Treatment	No. adults	% TYLCV	No. adults	% TYLCV
Hiles HDPE Black	622.1	1715.5	3715.5	1764.6
IPM Bromostop VIF	442.1	1509.5	---	---
Bromostop Shimmering VIF	---	---	2768.9	2062.3
Canslit Metalized	181.3	619.0	1584.3	1177.0
LSD, $P = 0.05$	240.0	490.2	1208.0	664.4
$F_{2,6}$	10.2	16.92	9.35	5.51
P value	0.01	0.003	0.014	0.044

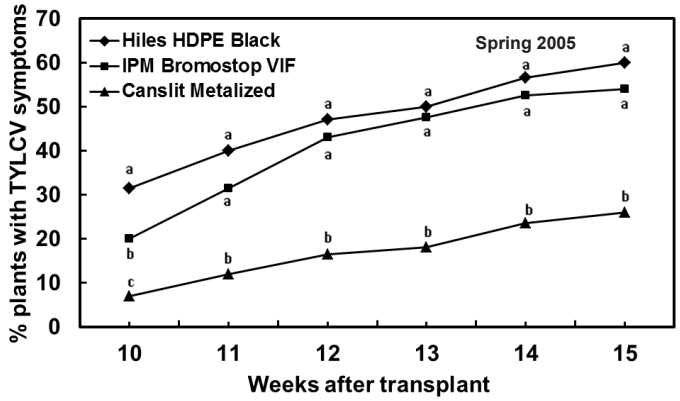

Fig. 3. The cumulative percentage of tomato plants with symptoms of *Tomato yellow leaf curl virus* (TYLCV) infection when the plants were grown on polyethylene soil mulches. Data points within a given week after transplanting with the same letter are not significantly different by Fisher's Protected LSD at $P = 0.05$

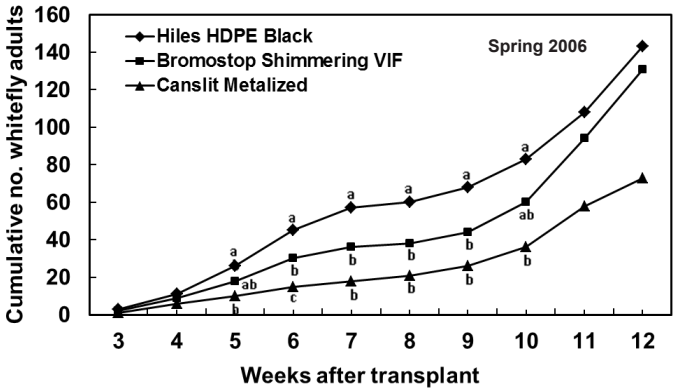

Fig. 5. The cumulative number of adult *Bemisia tabaci* observed on tomato plants grown on polyethylene soil mulches. Data points within a given week after transplanting with the same letter are not significantly different by Fisher's Protected LSD at $P = 0.05$. Data points with no letters are not significantly different.

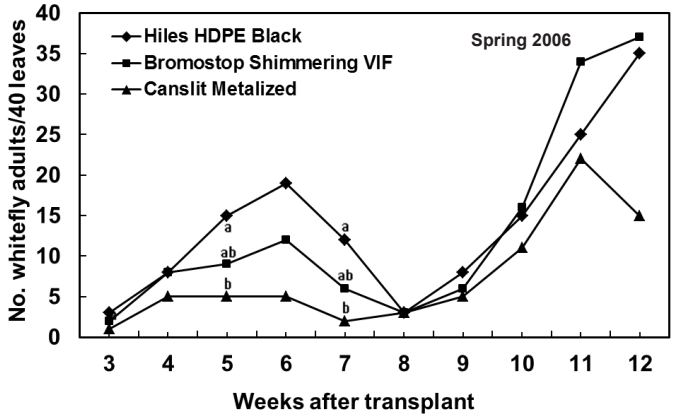

Fig. 4. The number of adult *Bemisia tabaci* observed on tomato plants grown on polyethylene soil mulches. Data points within a given week after transplanting with the same letter are not significantly different by Fisher's Protected LSD at $P = 0.05$. Data points with no letters are not significantly different

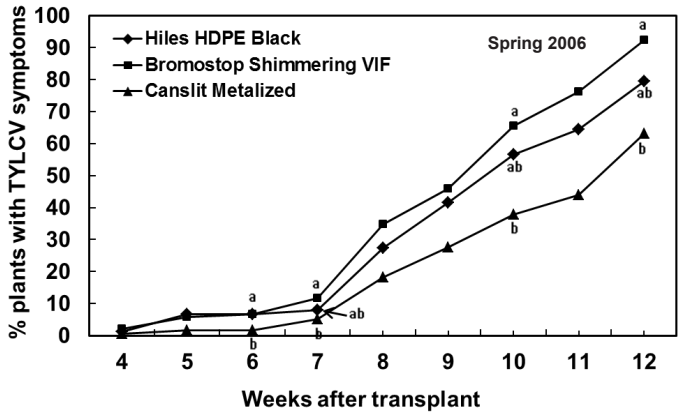

Fig. 6. The cumulative percentage of tomato plants with symptoms of *Tomato yellow leaf curl virus* (TYLCV) infection when the plants were grown on polyethylene soil mulches. Data points within a given week after transplanting with the same letter are not significantly different by Fisher's Protected LSD at $P = 0.05$. Data points with no letters are not significantly different.

mulches; however, when they did differ, the least were observed on plants on the metalized mulch. In contrast, the cumulative numbers of adults on plants on the metalized mulch were consistently lowest in both seasons, although differences between numbers on plants grown on white or black plastic were not consistent. Tomato plants grown on metalized mulch film consistently had a lower incidence of symptoms of TYLCV infection compared to tomato plants grown on white mulch in both years and compared to those grown on black plastic in 2005. Therefore, the use of metalized mulch film can be effective in reducing the numbers of *B. tabaci* adults settling over time on tomato plants grown on the mulch and in reducing the incidence of plants with symptoms

of the TYLCV they transmit. Metalized polyethylene mulch can be an important component of integrated programs for managing *B. tabaci* and TYLCV on tomato.

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