ments did not increase fruit size or resulted in earlier yields of large size fruits compared with water control in bell peppers or in tomatoes. Tomato yields were adversely affected by a severe infection of geminivirus that reduced fruit size and overall yields.

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ENDOSULFAN AND SILVER REFLECTIVE MULCH EFFECTS ON SWEET POTATO WHITEFLY POPULATIONS AND YIELDS OF ZUCCHINI SQUASH AND TOMATOES

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Abstract. **Sweet potato whitefly (*Bemisia tabaci* Gennadins) populations were monitored weekly during the spring growing season in zucchini squash (*Cucurbita pepo* L.) and tomato (*Lycopersicon esculentum* Mill.) plots treated with endosulfan and/or silver reflective mulch, or left untreated. Adult sweet potato whitefly populations increased in squash 50 days after seeding and were retarded by application of endosulfan. In tomatoes, buildup began 32 days after transplanting and was retarded by the endosulfan in combination with silver reflective mulch treatment. Sweet potato whitefly populations increased faster in the squash than in tomatoes. Endosulfan sprays in combination with silver reflective mulch delayed silver leaf symptoms on squash, but had no effect on fruit yield. The endosulfan sprays increased tomato yields and decreased internal fruit irregular ripening symptoms.**

The squash silver leaf disease was first reported on squash (*Cucurbita pepo* L.) in Florida during 1987 (2). Since that time the disease has become prevalent throughout the state and can cause significant economic losses (6). Squash silver leaf has also been reported in Israel (1). The symptoms first appear by the development of a silver coloration along the veins of younger leaves. The silvering becomes more intense as the leaves mature until the entire upper surface of the leaf is silver. In severe outbreaks fruit can also become lighter green or pale in color.

A related disease of tomatoes (*Lycopersicon esculentum* Mill.) is called irregular ripening (IR) (2). Irregular ripening symptoms are limited to the fruit which have irregular ripened areas on the exterior surface and/or white or yellow discoloration on the interior walls. Irregular ripening also causes considerable economic losses due to the unmarketability of many affected fruit.

Both the squash silver leaf and irregular ripening diseases are associated with the presence of the sweet potato whitefly, *Bemisia tabaci* Gennadius (2), and the involvement of the sweet potato whitefly in squash silver leaf has recently been documented (7). Control of the diseases, therefore, requires management of the sweet potato whitefly. Management of the sweet potato whitefly by a variety of insecticides has been extensively studied (3, 5). However, sweet potato whitefly can rapidly develop resistance to most chemicals (3); therefore, an integrated management strategy is a necessity. One additional component of an integrated management strategy that has been reported to reduce sweet potato whitefly populations is the use of aluminum-painted polyethylene mulch (4). The purpose of this investigation was to determine the influence of the insecticide endosulfan and aluminum-painted polyethylene mulch on zucchini squash and tomato yields, sweet potato whitefly populations, and incidence of squash silver leaf and irregular ripening diseases.

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Materials and Methods

Tomato experiment: 'Sunny' transplants (5 weeks old) were planted on 23 Feb. 1990 at the Agricultural Research and Education Center, Fort Pierce, FL. Raised beds, 8 inches in height and 44 inches wide, were spaced at 7-foot centers. Nutrients at 27-48-23 (lb N-P-K/acre) were incorporated in 44-inch wide bands and 103-67-212 (lb N-P-K/acre) fertilizer was split into two bands (24 inches apart) placed on the surface of each bed. Beds were covered with black polyethylene mulch. The main plot treatments consisted of: a) black polyethylene mulch (control), b) mulch coated with aluminum paint (Aluminum 11-31 Kool-Brite, Mobile Paint Manufacturing Co., Theodore, AL.), c) black mulch with weekly spray applications of endosulfan (0.31 oz/gal), and d) a combination of aluminum painted (silver) reflective mulch and weekly endosulfan (0.31 oz/gal) spray applications. Transplants were spaced 2 ft apart within a row placed in the center of each bed. Plots consisted of 15 plants. Plant population was equivalent to 3,111 plants/acre. Plots received weekly applications of maneb (0.95 oz/gal) and tribasic copper (0.7 oz/gal) for disease control. Tomatoes were harvested from the center 7 plants on 8, 15, and 29 May 1990. During each harvest, fruit from each plot was separated into marketable and culls, counted, weighed, and a subsample of fruit evaluated for external and internal symptoms of irregular ripening. Since only the last harvest (29 May) had symptoms of interior irregular ripening, the percentage of irregular ripening was calculated from each plot at the final harvest.

Squash experiment: 'Senator' zucchini squash was seeded (plug-mix with 5 seeds per hill) on 27 Feb. 1990. Each hill was thinned to one plant on 8 Mar. 1990. Identical bed construction, fertilization practices, pesticide program, plant spacing and arrangement, experimental design, plot size, and treatments were used as in the tomato experiment. Squash was harvested from the center 7 plants of each plot every Mon., Wed., and Fri. for a total of 19 pickings starting on 9 Apr. 1990. During each harvest, marketable fruits 6 inches or longer from each plot were counted and weighed. Plants from each plot were evaluated for silver leaf symptoms on 4 May 1990. Number of plants with silver leaf symptoms were converted into percentage of total plants in each plot.

Monitoring sweet potato whitefly: A 3 x 3 inch yellow sticky board (Great Lakes IPM) was placed 15 inches above the center of each plot. Adult sweet potato whitefly on each board were counted every 7 days, at which time new boards were placed in each plot. Sample whitefly specimens were evaluated taxonomically by Dr. Avis Hamon, Entomologist, Div. of Plant Industry, Gainesville, FL and determined to be sweet potato whitefly.

Statistical analyses: A randomized complete block design with each treatment replicated four times was used in both experiments. Each measured and calculated variable was subjected to analysis of variance (ANOVA). Treatment means were separated by a Duncan's multiple range test, 5% level.

Results

Adult sweet potato whitefly population increase on squash began 50 days after seeding (Fig. 1). However, this increase was retarded by endosulfan spray applications alone or in combination with reflective silver mulch. The silver reflective mulch had minimal or no effect on adult sweet potato whitefly populations in squash. After 85 days, adult sweet potato whitefly population increase had occurred in all treatments. In squash, adult sweet potato whitefly population increase was gradual rather than cyclical.

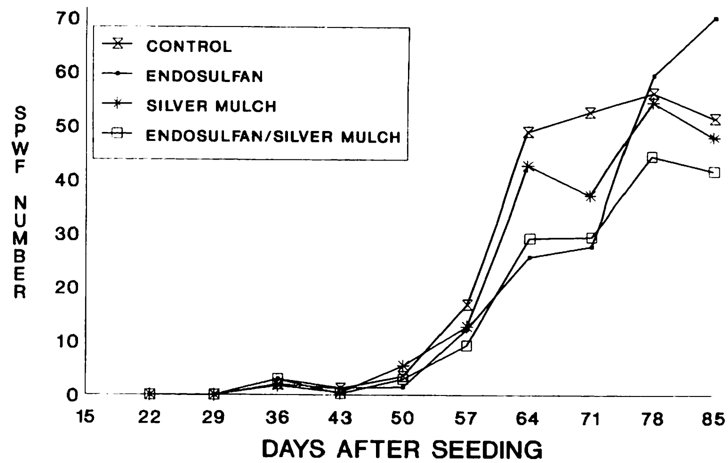

Fig. 1. Number of sweet potato whitefly adults collected on 3 x 3 inch yellow sticky boards in squash.

Squash yields were not affected by any of the treatments (Table 1). However, weekly endosulfan spray applications in combination with reflective silver mulch treatment significantly reduced the onset of squash silver leaf symptoms. At the conclusion of the experiment, 85 days after seeding, all plants in each plot had squash silver leaf.

Adult sweet potato whitefly were first detected in tomatoes 32 days after transplanting (Fig. 2), and populations subsequently increased in all treatments. The adult population increase was cyclical. Plots with weekly endosulfan applications in combination with reflective silver mulch consistently had fewer adult sweet potato whiteflies until 95 days after transplanting (final harvest) at the conclusion of the experiment.

Tomato yields were significantly increased by weekly applications of endosulfan (Table 2). Reflective silver mulch did not increase tomato yield. Plots with weekly endosulfan spray applications alone or in combination with reflective silver mulch reduced the incidence of irregular ripening.

Discussion

Weekly endosulfan spray applications delayed adult sweet potato whitefly buildup and squash silver leaf symptom development, but it did not affect squash yields. This suggests that the population levels of adult sweet potato whitefly in the experiment did not have a detrimental effect on squash and that squash silver leaf symptoms,

Table 1. Mean zucchini squash yields and silver leaf symptoms as influenced by sweet potato whitefly control strategies.

Treatment[z]	Marketable fruit (1000's/acre)	Marketable fruit (bu/acre)	Fruit size (oz/fruit)	SSL[y] (%)
Control	49.8	713	9.6	50.2 a[x]
Endosulfan	52.8	715	9.1	43.1 a
Reflective silver mulch	49.4	693	9.4	57.1 a
Endosulfan + reflective silver mulch	53.4	744	9.4	0.0 b

[z]Endosulfan sprays were applied weekly. Reflective silver mulch treatments consisted of coating the mulch with reflective aluminum paint.
[y]Percentage of plants with foliar veinal silver leaf symptoms.
[x]Mean separation by Duncan's Multiple Range Test, 5% level.

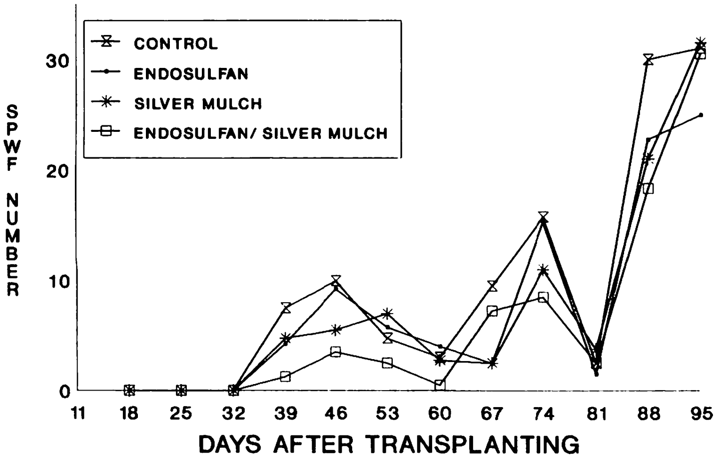

Fig. 2. Number of sweet potato whitefly adults collected on 3 x 3 inch yellow sticking boards in tomatoes.

at least if they appear late in the spring growing season, may not decrease yield. Those squash plots which received no insecticide produced good yields (713 bu/acre) (Table 1).

In contrast, the endosulfan spray applications resulted in tomato yields three-fold greater than those in unsprayed plots. A majority of this yield loss in tomato plants which did not receive endosulfan sprays was probably not due to sweet potato whitefly but other insects. A high incidence of leafminer, fruit worms, and secondary fungal infections were observed in the insecticide-free plots.

Many of the tomato fruit which appeared normal on the exterior had irregular ripening symptoms on the interior. Endosulfan sprays reduced incidence of irregular ripening in the otherwise marketable fruit. This reduction in irregular ripening is probably related to the lower levels of adult sweet potato whitefly in endosulfan-treated tomatoes.

Coating the mulch with aluminum reflective paint was not an effective strategy for sweet potato whitefly, squash silver leaf, or irregular ripening control. Although the number of adult sweet potato whitefly in plots treated with aluminum paint alone was somewhat less than the control (Fig. 1 and 2), the squash and tomato marketable fruit yields were unaffected. The lowest incidence of irregular ripening of tomatoes was with endosulfan plus reflective silver mulch. This was not significantly different than the amount of irregular ripening with tomatoes treated with endosulfan alone.

The adult sweet potato whitefly population levels in the experimental field plots were low as compared with many other regions of Florida. Some commercial fields may have adult SPWF densities 10 to 1000 times greater than those in these experimental field plots. Therefore, caution must be exercised in applying the data to situations in which the adult SPWF numbers are very high.

The data suggest that both endosulfan spray applications and reflective silver mulch are questionable practices for controlling SSL. However, the regular weekly application of endosulfan can greatly increase tomato yields and decrease the incidence of irregular ripening.

Table 2. Mean tomato yields and fruit damage as influenced by sweet potato whitefly control strategies.

fruit Treatment[z]	Marketable fruit per acre 1000's	Marketable fruit per acre 25 lb-boxes	Fruit size (oz/fruit)	Cull (%)	IR[y] (%)
Control	32 b[x]	456 b	5.8	48.5 a	48.2 ab
Endosulfan	110 a	1593 a	5.8	7.3 b	36.8 bc
Reflective silver mulch	40 b	588 b	6.0	41.8 a	56.6 a
Thiodan plus reflective silver mulch	113 a	1531 a	5.4	7.1 b	26.2 c

[z]Endosulfan sprays were applied weekly. Reflective silver mulch treatments consisted of coating the mulch with reflective aluminum paint.
[y]Percentage of fruits in the last harvest (May 24) with internal irregular ripening symptoms.
[x]Mean separation by Duncan's Multiple Range Test, 5% level.

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