REFERENCES CITED


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FOLIAGE DISORDERS IN FLORIDA ASSOCIATED WITH FEEDING BY SWEETPOTATO WHITEFLY, BEMISIA TABACI

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Sweetpotato whitefly, Bemisia tabaci (Gennadius), has been present in Florida for many years (Russell 1975) but until recently has not been regarded as a serious pest. Ornamental growers began to experience economically damaging outbreaks of this whitefly in 1986 on many plants in greenhouses. Feeding often resulted in chlorotic
spots at the nymphal feeding site. A new disorder of *Crosandra infundibularis* (L.) Nees characterized by chlorosis and distortion of new growth was reported by Osborne (1986), who postulated that this could be the result of a toxin produced by the whitefly during feeding.

In 1987, south Florida vegetable growers experienced outbreaks of the whitefly, and two new disorders, squash silverleaf and tomato irregular ripening, were widely reported. Although some reports noted the presence of whiteflies in affected squash plantings, others saw no clear association between *B. tabaci* and squash silverleaf (Simons et al. 1988). Hypotheses advanced to date attribute these disorders to environmental factors, nutritional deficiency, water stress, and whitefly-associated toxins or virus (Burger et al. 1988, Maynard & Cantliffe 1989, Simons et al. 1988, Yokomi et al. 1990).

Studies were begun in 1987 at the Central Florida Research and Education Center, Apopka, and in 1989 at the U.S. Horticultural Research Laboratory, Orlando, to determine if the presence of sweetpotato whitefly was associated with the occurrence of chlorosis and squash silverleaf.

Test plants were grown in greenhouses with natural lighting and a daily temperature range of 21 - 35 degrees C.

Association of the whitefly with foliar chlorosis in *Crosandra infundibularis* was examined using data obtained in pesticide efficacy trials after it was noticed that chlorotic plants began producing healthy new growth after pesticide applications. Pesticides were applied by spraying test plants to runoff. Test 1 (June 1987) treatments included: water; bifenthrin 10 WP (formulated as wettable powder, 10% active ingredient by weight), 2.41 g/liter; bifenthrin 10 WP, 2.41 g/liter plus acephate 75 S (solution, 75% by weight), 1.59 g/liter; potassium salts of fatty acids, 24.95 ml/liter; knoprene, 1.56 ml/liter; phosalone 3 EC (emulsifiable concentrate, 3 lbs per gallon), 3.34 ml/liter; aldicarb 10 G (granular, 10% by weight), 0.06 g/10 cm diameter pot; endosulfan 50 WP, 1.21 g/liter; acephate 75 S, 1.59 g/liter; and azadirachtin 0.3 EC, 3.32 ml/liter. Five plants per treatment were sprayed twice, one week apart. Test plants were infested prior to treatment by *B. tabaci* from a naturally occurring population present in the greenhouse. The nymphs were counted on days 7 and 14. For Test 2 (March 1989), 8 plants per treatment were sprayed 3 times at weekly intervals. The treatments used were: water; fenpropimorph 2.4 EC, 1.24 ml/liter; fenpropimorph 2.4 EC, 1.66 ml/liter; fenpropimorph 2.4 EC, 1.24 ml/liter plus acephate 75 S, 1.59 g/liter; fenpropimorph 2.4 EC, 1.66 ml/liter, plus acephate 75 S, 1.59 g/liter; methyl pirimiphos 5 E (emulsion, 5 lbs per gallon), 19.24 ml/liter; and rotenone 1% powder, 31.71 g/liter. Test plants were infested with naturally occurring *B. tabaci* in the greenhouse prior to the test; nymphs were counted before the first treatment and 7 and 14 days following treatment. Chlorosis was not noticeable on test plants at the start of the tests. Damage to new growth was rated on day 14 using a scale of 0 to 5, indicating a range from no chlorosis to entirely chlorotic new growth. Data were analyzed using Duncan's multiple range test (SAS-PC). Data from all treatments were then pooled to test for correlation of chlorosis with number of whiteflies present on each plant (SAS Institute 1985).

After 2 weeks the number of nymphs on treated plants was significantly lower than on controls (Table 1). Efficacy of treatments varied: the greatest reductions of whiteflies occurred with bifenthrin and fenpropimorph alone and when these were mixed with acephate, and with phosalone and methyl pirimiphos. Leaf chlorosis was positively correlated with number of immatures on the plant on day 14 (r = 0.91, p < 0.0001, n = 50 in Test 1; r = 0.72, p < 0.0001, n = 56 in Test 2; SAS-PC Pearson correlation coefficient).

The association of *B. tabaci* with squash silverleaf was investigated in 1989 using *Cucurbita pepo* (cv. "Senator") as the test plant. The effect of chemically controlling the whitefly upon the appearance of silverleaf was investigated with treatments of
<table>
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<td>15.4 a⁺</td>
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<td>11.6 ab</td>
<td>38.2 bc</td>
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<td>--</td>
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<td>--</td>
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<td>6.2 bcd</td>
<td>13.0 de</td>
<td>2.5 bcd</td>
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| **Test 2** |      |    |    |                  |
| water     | 55.4 NS | 125.9 a | 123.9 a | 4.4 a |
| fenpropathrin I | 53.0 | 43.3 b | 3.8 b | 2.0 bc |
| fenpropathrin II | 55.6 | 29.6 b | 2.0 b | 2.1 b |
| fenpropathrin + acephate I | 51.5 | 17.1 b | 0 b | 1.9 bc |
| fenpropathrin + acephate II | 51.8 | 6.9 b | 0 b | 1.5 c |
| pirimiphos-methyl | 55.5 | 21.3 b | 0.1 b | 2.4 b |
| rotenone | 53.6 | 46.5 b | 7.8 b | 2.0 b |

¹Rates and formulations given in text.
²No initial whitefly counts made in Test 1.
³I and II refer to low and high rates, respectively.
⁺Means within columns followed by same letter are not significantly different at (P = 0.05, Duncan's multiple range test). Tests 1 and 2 evaluated separately.
⁴Chlorosis of new growth was correlated with number of immature whitefly (r = 0.91, Test 1; r = 0.72, Test 2; Pearson correlation coefficient). 

bifenthrin 10 WP (4.78 g/liter) mixed with acephate 75 S (0.79 g/liter) and water controls. Seedlings were germinated inside screen cages and were 9 days old and free of whiteflies when moved into the test greenhouse and exposed to a naturally occurring population. Two trials with 10 plants per treatment were sprayed to runoff twice at weekly intervals, with the first spray occurring as soon as the seedlings were moved to the test greenhouse. Silverleaf severity was rated using a scale of 0 to 5; "0" being asymptomatic, "1" with veinlets surrounding areoles slightly lighter than surrounding tissue, "2" with the veinlets distinctly lighter than surroundings and presenting a characteristic netted appearance, "3" given when primary veins were bleached, "4" given when the bleaching extends into surrounding areoles, and "5" assigned to leaves entirely bleached. New leaves were first rated when expanded, at about 4 cm in length. Silverleaf symptoms were rated daily, and nymphs were counted on all leaves 15 days (trial 1) and 19 days (trial 2) after the second spray.

All water-treated controls developed silvering on new growth 9 to 11 days following exposure to adult whitefly; all insecticide-treated plants remained completely free of silvering. The mean number of immature whitefly per treated plant was 0.6 (S.D. 1.3,
range 0 - 5, all newly hatched crawlers) in trial 1 and zero in trial 2. The mean maximum silverleaf ratings of all affected leaves on water-treated plants were 4.5 and 4.9 in trials 1 and 2, respectively; the mean number of immatures per water-treated squash plant when rated was 88.1 (S.D. 42.7, range 22 - 185) in trial 1 and 98.5 (S.D. 40.8, range 47 - 167) in trial 2.

The effect of caging whitefly with squash on development of silverleaf was investigated using screen cages. Cages made of PVC tubing frames (0.72 m² collapsible field cage, Bioquip Products, Gardena, CA) were covered with number 72 mesh nylon chiffon screen. Adults used in these experiments were aspirated from plants in laboratory colonies reared at a constant 25 °C and 15 hour photoperiod on Hibiscus rosa-sinensis L., Euphorbia pulcherrima Willd. ex Klotsch, and Phaseolus limensis Macfady cv. Henderson bush lima bean.

In one set of experiments, adults were introduced to the treatment cage, while the control cage was placed adjacent to the treatment cage and kept free of whitefly. Four trials were conducted; the number of seedlings per cage in each trial varied from 12 to 24 depending on size of the plants. Seedlings had from 1 to 4 true leaves when placed in the cages. Approximately 200 to 1000 adults were released in the treatment cages. Leaves were inspected daily and the development of immatures recorded. Plants were rated for presence or absence of silverleaf symptoms. Adults were present and oviposited on all plants in the treatment cages.

Eggs began hatching on the fifth day after oviposition. Silverleaf symptoms appeared on new growth in the whitefly cages beginning on day 9. By day 11 all seedlings in treatment cages showed symptoms on new growth. Final observations were made on days 16 to 19. All plants contained immatures although numbers were not counted. All leaves that had formed prior to those on which silverleaf first appeared, on day 8, remained asymptomatic throughout the remainder of the trial, while all new growth was affected. None of the plants in the whitefly-free cage developed silverleaf symptoms.

In a second experiment, whitefly was introduced to 24 treatment plants by attaching two 3.5 mm diameter bean leaf discs containing 15 to 30 mature eggs and crawlers to the undersides of the first true leaf using diluted white aliphatic resin glue. Seedlings had 1 to 3 true leaves at time of exposure. After hatching, crawlers moved from the disc to the squash leaf beginning on the first day. All immatures remained confined to this leaf. Twenty-four control plants were given discs without whitefly. Leaves were monitored daily for 10 days for signs of silverleaf.

Silverleaf symptoms first began to appear on new growth of treatment plants 3 days after exposure to nymphs; by the fifth day symptoms were clearly visible on new growth of all treatment plants. Plants in whitefly-free cages did not develop symptoms. As in the previous experiment, all leaves that were formed earlier than the ones first showing silverleaf remained asymptomatic, and all subsequent growth was affected.

The effect of removing whitefly from squash seedlings already affected by silverleaf was investigated by removing all foliage containing any whitefly stages. Forty-eight plants of seven cultivars of C. pepo (zucchini, Senator, bush acorn, white bush, yellow crookneck, straight neck, and sugar pumpkin) were exposed in a greenhouse to whitefly; all plants contained immatures and all were affected by silverleaf. Leaves larger than 1 cm were removed, leaving only the smallest developing leaflets at the apical meristem. These remaining leaflets were inspected with a binocular microscope and were free of whitefly. Plants were examined daily for one week for signs of silverleaf. All new growth was asymptomatic. Thirteen of the seedlings exposed to whitefly by leaf disc as described earlier were further treated by removing the leaf with the immatures at day 10 and examining new growth daily for one week. The resulting plants were free of whiteflies. Leaves already showing silverleaf remained symptomatic; all new growth on all 13 plants was asymptomatic.
These results indicate that chlorosis of new growth in *Crossandra* and silverleaf of squash in Florida are directly correlated to the presence of *B. tabaci* on affected plants. Silverleaf symptoms were first visible nine to eleven days following exposure to adults and three to five days after exposure to nymphs. Current research is aimed at clarifying the significance of whitefly age on symptom induction. Silverleaf first appears in new growth at the apical meristem; further new growth is affected only as long as *B. tabaci* remain on the plant. This suggests that a phytotoxin associated with the whitefly may be involved in the etiology of the new foliage disorders.

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**References Cited**


