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Interaction of the Greenhouse Whitefly, *Trialeurodes vaporariorum* Westwood, and its Parasite, *Encarsia formosa* Gahan, on Tomato Cultivars[1]

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Abstract. **Distribution of the greenhouse whitefly and its wasp parasite, were measured on 12 cultivars of tomato, *Lycopersicon esculentum* Mill., by counting populations of parasitized and nonparasitized whitefly nymphs per leaflet. Parasitism percentages were similar on all cultivars despite large differences in whitefly populations. Second generation parasite populations correlated significantly with whitefly numbers (r=0.71**). "Pocketing" behavior significantly influenced whitefly distribution with minimal cultivar preference. However, distribution gradients showed that 'Floradel' was the center of 2 large pockets, indicating preference for it.**

The use of natural enemies to control greenhouse pests was reported by Speyer in 1927 (14) who advocated *Encarsia formosa;* (Hymenoptera: Aphelinidae) to control whitefly; (Homoptera: Aleyrodidae). Greenhouse environments may be modified to favor natural biotic control (7). Relatively constant greenhouse temp and humidity regimes reduce normal fluctuations in pest populations and aid prediction of pest build-up. Early observation determined that temp influences parasitizing efficiency of *E. formosa* (10, 14, 15). Burnett (2) found that fecundity and rate of development of both parasite and host are affected by temp changes and also reported (1) that *E. formosa* moves towards the drier end of a humidity gradient.

Biotic components of the environment also influence host-parasite relationships. *E. formosa* prefer to attack whitefly on nonpubescent plants (5, 10). Excretion and honeydew on plants also impede *E. formosa* efficiency (10). Decline in the reproduction rate of whitefly caused by host plant resistance, whether antibiosis or nonpreference, might increase *E. formosa* efficiency. Painter (11) reported the potential of host plant resistances as an aid to other control methods. Curry and Pimentel (4) found no significant resistance among 90 tomato cultivars tested to *T. vaporariorum* and in 2 cultivars were unable to detect any effect of cultivar resistance to whitefly on parasite (*E. formosa*)-host populations under controlled conditions (3). Tolerance also benefits the host-parasite interaction as both populations can be maintained without reducing tomato yields. Nicotine sulfate and resmethrin have been successfully integrated into control systems for whitefly without decreasing *E. formosa* populations (6).

This greenhouse study reports interactions of whitefly with its parasite *E. formosa* on 12 tomato cultivars. Totals of parasitized and nonparasitized whitefly nymphs on leaflets were used as an indication of cultivar susceptibility. Parasitized nymphs showed *E. formosa* distribution while parasitism percentages measured influence of cultivars on the parasite-pest interaction.

Seeds of 'Tuckcross O', 'Tuckcross 520', 'Tuckcross 533', 'Super M', 'Manapal', 'Floradel', 'Michigan-Ohio Hybrid', 'Jet Star', 'Missouri Hybrid 739', 'Missouri Hybrid 499', 'Missouri Hybrid 756', and 'Tropic' tomatoes were sown in vermiculite on July 15, 1973. They were transplanted on July 27 in 7 cm peat pots containing equal parts soil, peat, and expanded shale aggregate. On August 15, 2 whitefly adults per plant were released over plants. The plants were shaken periodically to keep the infestation uniform over all cultivars. Infested plants were spaced 46 x 74 cm in ground beds on August 17 in a randomized complete block design with 2 blocks, 4 plants to an experimental unit. Plants were pruned and trained to a single stem on a twine trellis. Thermostats were set at 15.5°C nights and monitored with hygrothermographs. Fan and pad cooling in the summer and perimeter steam in the late fall provided normal greenhouse growing temp.

E. formosa obtained from Bio Controls, Ontario, Canada, were released August 30 and Sept. 13 by stapling leaf sections containing from 10–20 parasitized nymphs to stakes placed between cultivars in the 2 center rows. Estimates of emerged parasites from the 2 releases were made by counting black nymphs with characteristic circular emergence holes. Weekly observations of uppermost leaves on each cultivar for black nymphs indicated parasite movement up the plant.

Estimates of whitefly populations were made once per leaflet by counting empty nymphal skins (emerged whiteflies) and the parasitized (black) nymphs. Two leaflets per leaf were counted on the first 10 leaves, and then half of the leaves from leaves 11 to 20. Parasitism percentage was the parasitized nymphs/total nymphs x 100.

Statistical analysis was Friedman's nonparametric analysis of variance (16) for data that did not meet the assumptions of normality and homoscedasticity.

Whitefly distribution. Mean no. of total whitefly nymphs/leaflet ranged from 13 to 36 between blocks. "Pocketing", an inherent whitefly behavioral pattern where large populations occur in relatively small areas (10, 12), produced much of the variation. Fig. 1A illustrates horizontal pocketing of whitefly nymphs between and within cultivars on the first 20 leaves above the ground bed. Whitefly nymphs were consistently high on 'Floradel' where 2 large pockets centered. Initial preference for 'Floradel' did not prevent migration to surrounding plants. Friedman's nonparametric analysis of variance indicated significant differences (α=0.24) in whitefly populations among cultivars (Table 1). However, none of the cultivars exhibited high resistance.

Parasite distribution. Distribution of parasites was similar to whitefly populations (Fig. 1B). Correlation of emerged whitefly and parasitized nymphs/leaflet showed that released parasites on leaves 1–10 less consistently found and parasitized the increaing whitefly nymphs/leaflet than 2nd and 3rd generation parasites did on leaves 11–20 (r=0.58** vs. r=0.71**). Effects of whitefly populations on parasite distribution over time are shown by the 3-fold difference in whitefly nymphs between blocks with parasitism percentages remaining nearly equal (61 vs. 65%).

Host plant influence on parasite-pest interactions. Although parasite preference was largely influenced by whitefly distribution, parasitism percentages differed slightly among plants. The small differences suggest that host plants may affect parasite-pest interactions. 'Tropic' had the lowest parasitism percentage among cultivars, but the reduction was in Block I only. Analysis of parasitism percentages (Table 1) indicated differences among cultivars at the α=0.25 level. Although air flow in the greenhouse reduced the chance for contamination from chemical drift, 'Tropic' was closest to sources of possible contamination that we may have

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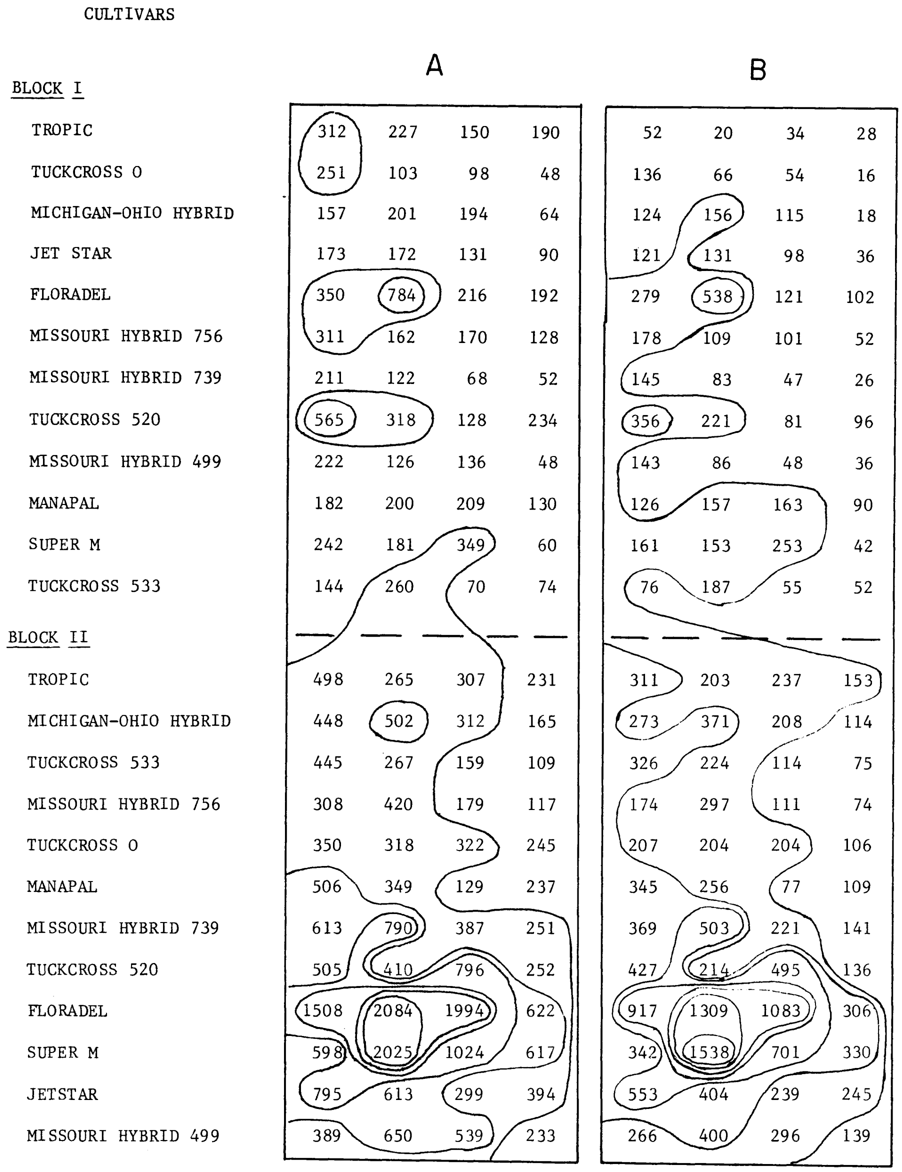

Fig. 1. A. Whitefly nymph distribution (no./plant) for leaf positions 1–20. Contour lines separate counts of 250 nymphs. B. Parasitized nymph distribution (no./plant) for leaf positions 1–20. Contour lines separate counts of 150 nymphs.

Table 1. Infestation among 12 tomato cultivars by greenhouse whitefly and parasitism by *Encarsia formosa.*

Cultivar	No. of whitefly nymphs	Parasitism (%)
Floradel	969	62
Super M	637	70
Tuckcross 520	401	63
Jet Star	333	68
Mo. Hyb. 739	312	63
Mo. Hyb. 499	293	60
Tropic	272	42
Mich.-Ohio Hyb.	255	67
Manapal	243	69
Mo. Hyb. 756	224	60
Tuckcross 0	217	56
Tuckcross 533	191	71
	α=0.24[z]	α=0.25[z]

[z]Analysis by Friedman's nonparametric rank test.

reduced parasite activity. The dangers associated with nonselective chemicals in and around greenhouses using *E. formosa* cannot be overlooked.

Temperature. Temp ranging from 10°C (nights) to 35° (days) were not considered detrimental. Burnett (2) found that *E. formosa* control whitefly best above 24°. Scopes (13) showed that *E. formosa* pupae could be stored at 12° to aid timing of release, but temp below that reduced emergence. We successfully cooled *E. formosa* pupae for 1 week at 4.5° before the second release, so *E. formosa* populations may differ in cold tolerance.

Release rates. An average of 8.8 adult parasites/plant emerged from the initial release; 7/plant, from the second release. *E. formosa* migrated extensively within the greenhouse, contrary to Burnett's report (1) that adult parasites do not move far from ovipositing sites. Parasites released would equal only 1 adult per 0.2 m^2 (½ ft^2) of greenhouse space or 15.8 parasites/plant. This was much higher than used for cucumbers (7), but considering total greenhouse area, only half the number recommended by McLeod (9) and others (8, 12). Parasitism percentage (60% by released *E. formosa*) might have been higher had more been released. A more accurate system for determining the optimum number of *E. formosa* for release should be developed. Such a system might consider both volume and the unplanted areas of the greenhouse.

In summary, growth habits of the cultivars apparently did not adversely affect efficiency of *E. formosa,* and lack of comparative resistance resulted in similar host-parasite relationships among cultivars. The "pocketing" behavior of whiteflies was more significant than differences in susceptibility among cultivars.

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