Effect of Tomato Cultivar and Fertilizer Regime on the Survival of *Liriomyza trifolii* (Diptera: Agromyzidae)

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ABSTRACT A comparison of host-plant suitability was made with *Liriomyza trifolii* (Burgess) reared from chrysanthemums (*Chrysanthemum morifolium* Ramat) on selected cultivars of tomato (*Lycopersicon esculentum*; 'Big Boy', 'Cherry', 'Early Girl', 'Patio', 'Supersteak', 'VF 6718', and 'VF 7718'). Mean numbers of pupae or adults per plant and the survivorship of pupae and emergence of adults were used as criteria to analyze the suitability of these cultivars as hosts. Little survival was observed on six of the seven cultivars. Lowest (0.24) and highest (0.60) percentage of pupa survival was obtained with the cultivars 'VF 7718' and 'VF 6718', respectively. The suitability of two cultivars, 'Patio' and 'Beefsteak', as hosts for *L. trifolii* was significantly improved by increasing total fertilizer delivered to the plant. Higher fertilizer levels increased plant size, larva survival, and size of pupae. The effect of tomato cultivar and fertilizer regime on development of *L. trifolii* and the possible movement of this species from a bedding-plant nursery to commercial tomato fields are discussed.

KEY WORDS *Liriomyza trifolii*, tomato, nitrogen, survivorship, bedding plants

BEDDING-PLANT NURSERIES in the United States produced a crop valued at ca. 274 million dollars in 1984 (Voigt 1985). Five species (impatiens, petunias, geraniums, marigolds, and tomatoes) dominate production (Voigt 1985), but most nurseries grow at least 50 different species of ornamental and vegetable plants. Pest problems are often compounded by the close proximity of vegetables and ornamentals, particularly with polyphagous pest species (Robb et al. 1986).

Four species of dipteran leafminers (Agromyzidae) have been found attacking bedding plants in California (Parrella & Robb 1982). The most serious of these is *Liriomyza trifolii* (Burgess), because of its short development time, polyphagous nature, high reproductive rate, and ability to develop resistance to insecticides (Parrella et al. 1983, Parrella & Keil 1984). The conspicuous damage caused by the mining of the larvae can seriously reduce the marketability of bedding plants, many of which are destined for retail nurseries for eventual purchase of homeowners. Of more concern is that some nurseries grow tomatoes and other vegetables for transplant into commercial vegetable-production fields in California. Thus, movement of pests from ornamental to vegetable crops at a nursery could lead to their eventual establishment in vegetable-growing areas of the state. Indeed, the tomato pest management guide for California (University of California 1985) recommends that all transplants be free of pests before placement in the field.

The establishment of *L. trifolii* in many bedding-plant nurseries has occurred through acquisition of chrysanthemum plants infested with this leafminer (Parrella & Robb 1982). Chrysanthemums rank among the top 15 crops grown at bedding-plant nurseries (Voigt 1985). From this infestation originating in chrysanthemums, *L. trifolii* has spread to many other plant species grown at nurseries.

Our studies were conducted to determine if *L. trifolii* from chrysanthemums could infest tomatoes in a bedding-plant nursery; whether differences exist in suitability among selected tomato cultivars as hosts for *L. trifolii*; and whether the heavy fertilizer regime commonly used at most bedding-plant nurseries influences the suitability of tomatoes as a host for this leafminer.

Materials and Methods

A colony of *L. trifolii*, originating from chrysanthemums at bedding-plant nurseries in southern California, was established in the greenhouses at the University of California, Riverside. Colony size on chrysanthemums ('White Hurricane') was kept at ca. 2,000 adults, and leafminer colony production was such that flies were added daily. Wild flies from this host were added whenever possible.

Tomato cultivars ('Big Boy', 'Cherry', 'Early Girl', 'Patio', 'Supersteak', 'VF 6718', and 'VF 7718') were obtained as seedlings in six-plant packs

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from bedding-plant nurseries and repotted into 10-cm pots. They were allowed to reach the 10-leaflet stage (ca. 30 cm tall) before exposure to the fly colonies. All cultivars were kept on raised greenhouse benches under a combination of artificial and natural light with a photoperiod of 14:10 (L:D), and received weekly applications of modified (4-fold the normal iron) Hoagland solution (Association California Fertilizer 1980). Five plants were exposed at the same time to the colony of *L. trifolii* for one 2-h midday period, thus assuring that egg deposition and larva development would be synchronized. Sufficient numbers of plants (10–25) were exposed to assure that ca. 200 larvae were evaluated per cultivar. At the beginning of the experiment, one extra plant of each cultivar was used to determine total nitrogen. All leaves from this plant were pooled and total nitrogen was determined by the Kjeldahl method (McKenzie & Wallace 1954).

After removal from the cage, plants were placed on the same greenhouse benches and newly eclosed larvae were counted per tomato leaflet 3–4 days later. Leaflets with five or more larvae were removed in these tests to eliminate possible effects of intraspecific competition on larva survival (Parrella 1983). Leaflet removal was uncommon, with no more than one or two leaflets removed per plant. Mines in these leaflets were not included in the evaluation of mean number of mines per plant. Before larva emergence from the leaflets, plants were tipped over trays of sand in an environmental chamber at 26.7°C, 70% RH and a photoperiod of 14:10. Pupae were collected and counted; their lengths were measured with an ocular micrometer. They were subsequently held in small plastic vials in the environmental chamber until adults emerged. Host-plant suitability was evaluated on the percentage of larvae surviving to pupation, the size of pupae (Parrella 1983), and the percentage of pupae surviving to adults for each of the tomato cultivars tested on a per-plant basis. These data were transformed using an arcsine square-root transformation before analysis of variance with Duncan's (1955) multiple range test to detect differences among the cultivars ($P < 0.05$).

In the fertilizer study, low, medium, and high fertilizer regimes were altered for the 'Patio' and 'Beefsteak'. This was accomplished by providing one group with no fertilizer after transplanting into 10-cm pots (low); one group with modified Hoagland solution (200 ml per pot), once per week (medium); and one group with modified Hoagland solution (200 ml per pot) plus Osmocote (14-14-14) (ca. 6 g per pot). The suitability studies were set up in a randomized complete-block design with four plants per treatment per cultivar. Blocking was done through time with exposures completed over a 3-week period (12 plants per cultivar). At the time the plants were used, total nitrogen content of the leaves was calculated using eight additional plants per treatment per cultivar. An additional 10 and 5 plants were used to compare plant height and leaf area, respectively, for the different treatments and cultivars.

Table 1. Suitability of selected tomato cultivars as hosts for *L. trifolii*

Cultivar	n[a]	$\bar{x}$ no.[b]			$\bar{x}$ survival (%)[b]	
		Mines/plant	Pupae/plant	Adults/plant	Pupae/mines	Adults/pupae
'VF 6718'	18	19.9a	12.0a	9.3a	0.60a	0.72a
'Patio'	14	18.8a	9.4ab	8.0ab	0.39b	0.78a
'Cherry'	20	18.3a	7.3bc	5.0bc	0.38b	0.63a
'Supersteak'	20	15.9a	6.5bc	4.7bc	0.36b	0.65a
'VF 7718'	19	15.8a	4.6bc	2.7c	0.24b	0.51a
'Big Boy'	20	15.3a	4.1c	2.7c	0.24b	0.55a
'Early Girl'	15	14.7a	4.0c	2.3c	0.27b	0.52a

[a] n, number of plants exposed to ovipositing flies.
[b] Means in the same column followed by the same letter are not significantly different ($P > 0.05$; Duncan's [1955] multiple range test).

Results and Discussion

In general, larva mortality was high but mean numbers of pupae and adults per plant differed significantly among the cultivars (Table 1). The cultivars 'VF 7718' and 'VF 6718' had the lowest and highest percentage of pupae surviving (0.24 and 0.60, respectively).

Mean percentage of adults emerging did not differ significantly among cultivars. This suggests that potential antibiosis in tomatoes affects the larva stage and there is little effect after pupation. Therefore, percentage of adults emerging from pupae is not as useful an indicator of host suitability as the mean percentage surviving to pupation.

Pupa sizes from all cultivars did not differ significantly. Any effects of cultivar on pupa size may have been obscured by large differences in the sizes of male and female pupae, which were not separated in this study.

In the first experiment, where tomato cultivars were compared for suitability, the average total nitrogen content was 1.49% ± 0.3 ($\bar{x} \pm$ SD, n = 49) per plant for all varieties. This level is low, but is sufficient for production of field-grown tomatoes in California (University of California 1985).

In the second experiment, where fertilizer was manipulated, suitability of tomatoes as a host for *L. trifolii* was influenced profoundly. On both 'Patio' and 'Beefsteak', significantly higher numbers of pupae and adults were recovered, and there was a larger percentage of pupae surviving in the high-nitrogen treatment than with low and medium fertilizer levels (Table 2). Little difference was noted when the various parameters were compared between low and medium nitrogen treatments, probably because the medium nitrogen level was only slightly higher than the low level. However, the percentage of pupae surviving was sig-

Table 2. Effect of total leaf nitrogen on the suitability of two tomato cultivars as hosts for *L. trifolii*

Total leaf nitrogen ($\bar{x}$ % ± SEM)	Plant characters ($\bar{X}$) Ht (cm)	Area (cm^2)	$\bar{x}$ no.[a] Mines/plant	Pupae/plant	Adults/plant	$\bar{x}$ survival %[a] Pupae/mines	Adults/pupae	$\bar{x}$ pupal length (mm)[ab]
'Patio'								
Low (0.95 ± 0.21)	16.7a	148.3a	30.6a	7.1a	5.0a	0.17a	0.67ab	1.41b
Medium (1.20 ± 0.17)	24.1b	307.6a	42.0ab	12.3a	8.4a	0.28b	0.61a	1.35a
High (2.63 ± 0.79)	39.0c	728.6b	53.3b	47.1b	39.9b	0.88c	0.85b	1.51c
'Beefsteak'								
Low (0.98 ± 0.20)	28.8a	236.2a	19.4a	4.0a	2.8a	0.21a	0.79ab	1.36a
Medium (1.03 ± 0.19)	32.0a	272.3a	29.8a	17.3b	12.3a	0.52b	0.60a	1.43b
High (2.35 ± 0.77)	57.4b	755.0b	46.3b	40.4c	33.3b	0.87c	0.81a	1.49c

[a] Means in the same column followed by the same letter within cultivars are not significantly different ($P > 0.05$; Duncan's [1955] multiple range test).
[b] $n = 84$, 133, and 582, respectively, for low, medium, and high nitrogen with 'Patio'. $n = 48$, 185, and 457, respectively, for low, medium, and high nitrogen with 'Beefsteak'.

nificantly higher with the medium compared with the low fertilizer level.

Percentage of adults surviving was not a useful indicator of host-plant suitability, as noted in the first experiment. Significantly larger pupae were recovered from the higher fertilizer treatment than from the other two levels with both cultivars, despite the fact that the sex of pupae was not determined. The overall greater vigor of the tomato plants with higher fertilizer, as indicated by significant differences in height and leaf area (Table 2), suggests that *L. trifolii* probably would find them to be more suitable hosts. The smaller leaf area of plants grown under the medium and low nitrogen regimes did not affect larva survival because leaflets with five or more larvae were eliminated, as in the first experiment. Previous studies have demonstrated the importance of leaf nitrogen content to the development of many insect species (Mattson 1980). This has been demonstrated for *Liriomyza* spp. in various crops (Woltz & Kelsheimer 1958, Poe et al. 1976, Harbaugh et al. 1983). We speculate that leaf nitrogen content influenced the survivorship of *L. trifolii* on tomatoes in this study, but with other potentially critical elements varying in the fertilizer treatments, this cannot be substantiated. The possibility that increased fertilization affected physical parameters of the leaf (e.g., leaf toughness) was not investigated.

In summary, tomatoes can serve as a host for *L. trifolii*, but suitability will be dependent upon cultivar and the amount of fertilizer the plants receive. It is unknown whether antibiosis by the tomato plant was responsible for death observed under lower fertilizer regimes, or whether there was simply a lack of proper or specific proteins for *L. trifolii*. Webb et al. (1971) showed that several lines of *Lycopersicon esculentum* exhibited antibiosis to *Liriomyza sativae* Blanchard larvae (*L. munda* in Webb et al. [1971]). In the present study, many larvae of *L. trifolii* died before reaching the later instars; their mines remained smaller and darker than the normal serpentine mines made by this species.

With tomatoes in the field, where total foliar nitrogen levels range between 3 and 5% during the season in California (J.T.T., unpublished data), our data suggest that *L. trifolii* could become a serious pest. In bedding-plant nurseries where *L. trifolii* has been introduced primarily on chrysanthemum cuttings (Parrella & Robb 1982), this species may use tomatoes as a host. This may be more common in nurseries where tomatoes and chrysanthemums are grown side by side. Total nitrogen levels of 'Beefsteak' and 'Patio' originating from a bedding-plant nursery exceeded 3.5%, which suggests that these and other cultivars would be adequate hosts for *L. trifolii*. Transplanting infested cultivars in the field could lead to rapid establishment of *L. trifolii* in tomatoes in the field. This species has already displaced *L. sativae* as the major leafminer species attacking tomato in west Florida (Schuster et al. 1982) and there are indications that this may also be occurring in California (Zehnder & Trumble 1984).

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