Leafminer larvae mine the inside of tomato leaves, severely reducing photosynthesis.

The vegetable leafminer on fresh market tomatoes in southern California

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Most of California's fresh market tomatoes, a crop valued at $161.1 million in 1981, are grown in San Diego, Orange, Ventura, San Joaquin, Merced, and Fresno counties. In southern California, growers may establish tomato plantings from early February through mid-July. Planting dates (spring, summer, fall) are influenced by the market, especially the spring and fall crops, which usually are more profitable.

Insect pests that need to be controlled to limit crop losses vary, depending on the planting time (fig. 1). Most insecticide treatments applied on fresh market tomatoes are directed against the tomato fruitworm, *Heliothis zea* (Boddie), the tomato pinworm, *Keiferia lycopersicella* (Walsingham), and the beet armyworm, *Spodoptera exigua* (Hübner), which feed in and on the fruit. Depending on the insecticides used in these treatment regimes, two additional pests may increase to high numbers: the vegetable leafminer, *Liriomyza sativae* Blanchard, and a second, newly imported, agromyzid species, *Liriomyza trifolii* (Burgess) (see *California Agriculture*, Sept-Oct. 1981). This discussion is limited to *L. sativae*, currently the predominant agromyzid species on fresh market tomatoes in southern California.

Biology

The vegetable leafminer mines the foliage of tomato and many other plant species. Mated females insert their eggs into the upper surface of tomato leaflets. After hatching, the young larvae begin mining the palisade layer and remain in the leaflet until three larval stages (instars) are completed. During the warmer months, *L. sativae* larval development requires about four days from hatching to pupation. Mature third-stage larvae exit from the leaflet, and most drop to the ground to pupate. However, some larvae pupate on the calyx end of the fruit and on leaflets. Adults emerge from the puparia in about seven to ten days depending on the temperature.

Feeding punctures and egg-laying wounds that result from insertion of the female's ovipositor cause minor injury to leaflets. Such wounds kill localized groups of cells, which later appear as chlorotic depressions in the leaflet.

Larval mining causes greater injury; each mine involves about 0.04 square inch of leaflet area as viewed from the upper leaf surface. Recent field studies show that photosynthetic rates within mined tissues are reduced about 62 percent as compared with unmined tissue. Reductions in photosynthesis in unmined tissues of mined leaflets are correlated with the percentage of mining within the leaflet ($r = -0.68$). Thus, small areas of mining cause larger total reductions in phototsynthesis than would be expected. It has been estimated that about 18 percent mining injury results in a 60 percent reduction of total leaflet photosynthesis (equivalent rate of mined tissue) when reductions in the adjacent unmined tissues are considered.

Although mining injury appears to reduce photosynthesis greatly, physiologists suspect that the tomato plant produces more assimilates than are actually required for growth and fruit production. This may explain difficulties researchers have encountered in demonstrating reductions in tomato yields as a result of *L. sativae* infestations.

Natural control

Under natural conditions, vegetable leafminer populations usually are not sufficiently high to warrant control measures. This has been observed in several crops, especially tomatoes, where 14 species of parasitic Hymenoptera use the vegetable leafminer as a host. Some of the most common parasites are *Diglyphus begini* (Ashmead) and *Chrysonotomyia punctiventris* (Crawford), which complete their total development on leafminer larvae. Other parasites include *Chrysocharis parksi* Crawford, *C. ainsliei* Crawford, and *Halticoptera* spp., which deposit their eggs in late-stage host larvae. The parasite larvae then complete their development inside the leafminer puparia. Such species as *D. begini* and *C. parksi* also feed on the host, causing additional mortality in the leafminer population. Host-feeding involves intake of leafminer body fluids by the female parasite after puncturing the leafminer larvae with her ovipositor.

Field studies on natural populations of vegetable leafminer, conducted at the UC South Coast Field Station (SCFS) in Orange County, indicated that the proportion of the leafminer larval population surviving to the adult stage decreased from 0.44 to 0.02 as both the host larval population density and the total proportion of larval and larval-pupal parasitization increased. This trend is characteristic of density-dependent mortality and has been observed in some form in all insect populations controlled by natural enemies.

Pesticide-induced upsets

Studies conducted at the SCFS from 1975 through 1982 have shown repeatedly that weekly scheduled applications of methomyl for lepidopterous larval control on fresh market tomatoes result in density increases in vegetable leafminer populations. This happens because the insecticide suppresses the leafminer's effective natural enemies but not the leafminer.

In 1976, methomyl, a broad-spectrum insecticide, at 0.5 and 1 (recommended) kg active ingredient per hectare, and Dipel (*Bacillus thuringiensis* Berliner var. *kerstaki*), a selective biotic insecticide, at 0.56 kg active ingredient per hectare, were investigated to determine their effect on the leafminer and its parasites. Comparisons were made with an untreated check.

Although the vegetable leafminer population was high in all treatments early in the season, it was reduced significantly by natural enemies in the Dipel and untreated check plots as the season progressed (fig. 2). However, vegetable leafminer populations continued to increase in the methomyl plots until early September. Comparison of the number of externally parasitized larvae

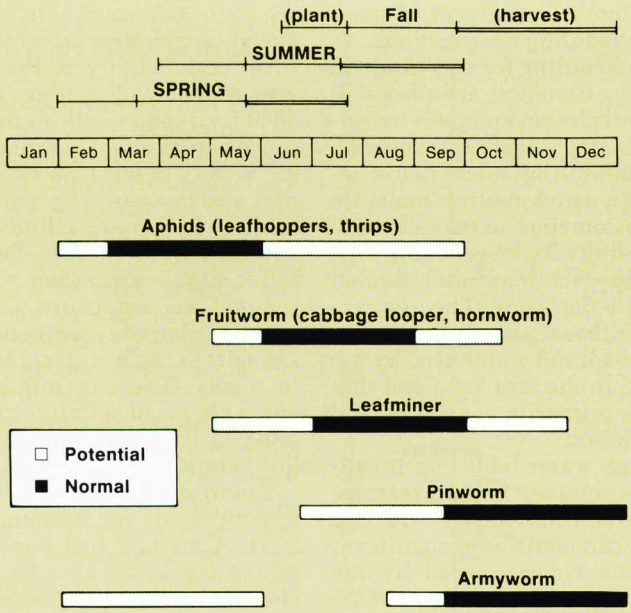

Fig. 1. Insects that cause losses of fresh market tomatoes vary depending on planting time in southern California.

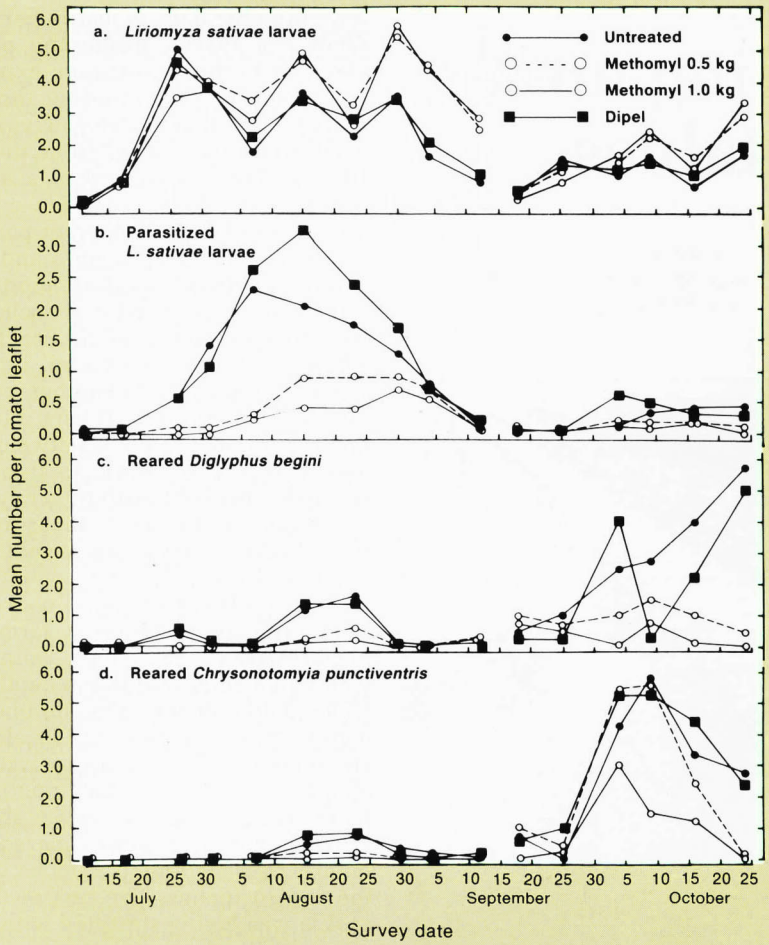

Fig. 2. Secondary pesticide effects on vegetable leafminer and its parasites. As season progressed, Dipel and untreated plots had fewer leafminers (a), higher parasitization (b), and more parasites (c, d) than plots treated with methomyl.

per leaflet in the various treatments showed that parasitization was high in the Dipel and untreated check plots as compared with the methomyl plots. Emergence of adult *D. begini* and *C. punctiventris* parasites reflected the same trend. The natural enemies, however, were not totally eliminated in the methomyl treatments, and some parasitism did occur.

Thus, occasional use of methomyl probably would not increase the vegetable leafminer greatly. The use of Dipel may be desirable, because lepidopterous larval-induced feeding damage to tomato fruit was not significantly greater in the Dipel treatment than in the methomyl treatments in this study.

Monitoring leafminer populations

Several sampling techniques have been developed to monitor *Liriomyza* spp. mining tomato foliage. These include foliage examination (actual counts and rating systems), trapping flying adults on yellow sticky cards placed in the field, and trapping mature leafminer larvae as they fall from the foliage to pupate. The last-mentioned technique employs the use of 9- by 11- by ⅝-inch Styrofoam trays placed under the tomato foliage. The smooth surface texture of the trays prevents leafminer larvae from escaping, and they eventually pupate therein. Use of the "pupa trays" has gained wide acceptance in southern California, where rainfall patterns do not interfere with trap catches. Currently, UC Riverside entomologists are studying the effects of leafminer densities on tomato fruit yields. They are using the pupa trays to standardize estimates of leafminer densities for the timing of insecticide applications.

Current status and control

Presently, the vegetable leafminer is a minor pest of fresh market tomatoes and can be readily controlled with available insecticides when populations become large. The systemic compound, oxamyl, is frequently injected through drip irrigation lines, and has proved effective in controlling the vegetable leafminer. Foliar applications of fenvalerate or permethrin (which may be used only if registered locally) also provide adequate control.

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