Insecticide resistance in *Liriomyza trifolii*

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During the past four years, chrysanthemum growers have had difficulty controlling the leafminer with currently registered insecticides. California therefore obtained a "24c" special local needs registration for permethrin (Pounce) in 1979 and for microencapsulated methyl parathion (Penncap M) in 1980 for use against leafminer on greenhouse-grown chrysanthemums. Failure of these materials to provide control was suspected in the summer of 1981 in northern California, and their failure was documented in southern California in the summer of 1982.

The relatively short field-life of these "new" compounds suggests that this leafminer, *Liriomyza trifolii* (Burgess), has an enormous capacity to develop resistance to insecticides. An important part of insect pest management is to monitor the inherent toxicity of registered pesticides to target species to prevent, or at least delay, the development of resistance. This was not possible with *L. trifolii*.

An introduced species

This leafminer has been an important pest of horticultural and agronomic crops in Florida for 30 years but does not occur naturally in California. It is suspected that this species was introduced into California from Florida during the late 1970s on chrysanthemum cuttings and celery transplants. Today in California, this insect is recognized as the primary pest of chrysanthemums and numerous bedding plants (verbena, calendula, and the like). In addition, it has been implicated as a major leafmining species causing damage on celery and tomato.

To evaluate this leafminer's ability to develop insecticide resistance, we need to know its history of exposure to insecticides in Florida. Most classes of insecticides (chlorinated hydrocarbons, organophosphates, carbamates, pyrethroids) have been intensively used against the leafminer on Florida vegetable and ornamental crops. During the past 10 years, the average effective field-life of an insecticide used against this species in Florida has been less than three years. This information is consistent with the relatively short-term effectiveness of permethrin and microencapsulated methyl parathion in California. Research to characterize the development of resistance in *L. trifolii* was undertaken in an effort to understand how to control this pest.

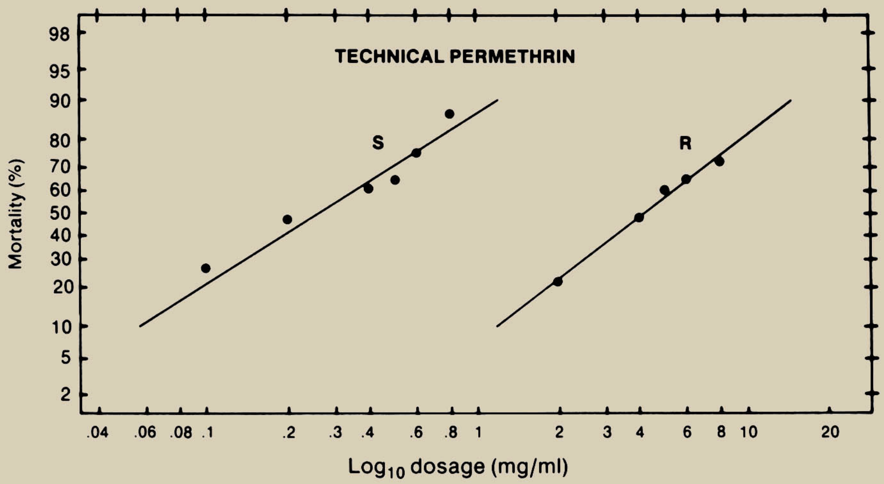
Rapid buildup of insecticide resistance may cause problems in California crops

Documentation of resistance

The first step in defining the development and magnitude of insecticide resistance in a species is to obtain a susceptible population as a basis for comparison. A completely susceptible population of this leafminer is difficult to locate because of the fly's introduced status. All flies in California probably have a past history of exposure to numerous insecticides, but they probably have had limited exposure to pyrethroid insecticides. However, we were able to identify populations of *L. trifolii* under different degrees of insecticide selection pressure in California and could, therefore, compare responses to the "new" 24c registered insecticides in California.

The suspected susceptible strain (S strain) was collected from a bedding plant nursery in Los Angeles County; the major host plants were calendula and dahlia. This leafminer population is characterized by infrequent pesticide applications, usually consisting of methomyl for caterpillar control. Permethrin has never been used at this location, and methyl parathion is not used on these bedding plants. In contrast, the suspected resistant strain (R strain) was collected from a chrysanthemum grower in San Diego County where applications of permethrin plus microencapsulated methyl parathion as a tank mix were made approximately 70 times per year.

We established greenhouse colonies from both locations for resistance studies at the University of California, Riverside, and set up rearing procedures to ensure large numbers of adult flies of a known age for testing. The methodology consisted of topical applications of technical insecticide in acetone (0.6 microliter per fly) to lightly anesthetized (CO_2) female flies about three days old. After application, adults were transferred to 25-dram plastic containers, each holding a fresh chrysanthemum leaf and a supply of honey. The insecticides permethrin or methyl parathion were tested on the S and R strains, using five or six dosages per insecticide, including an untreated control. There were four replicates per dose with 20 flies per replicate. Mortality was record-



Dose-response lines of susceptible (S) and suspected resistant (R) strains show development of resistance in R strain. (Each data point is a mean from 80 adult female flies less than 3 days old.) LD_{50} values can be obtained by reading across from the 50% mortality value to the S and R lines, and then down to the dosage value.

ed after 24 hours (and corrected using Abbott's formula). Control mortality was typically low (less than 5 percent).

Comparing the dose-response lines of the S and R strains to permethrin reveals that resistance has developed in the R strain. Approximately a 17-fold difference in the LD_{50} values (the dosage of insecticide required to kill 50 percent of the test animals) is found between the resistant (LD_{50} = 4.30 mg per ml) and susceptible (LD_{50} = 0.26 mg per ml) strains. We suspect that resistance to permethrin probably developed from past exposure to nonpyrethroid insecticides such as DDT in Florida. With methyl parathion as the test insecticide, an approximate 3-fold difference in LD_{50} values was found between the R and S strains (LD_{50} = 5.29 mg per ml and 1.53 mg per ml, respectively). Applications of methyl parathion or permethrin as wet sprays are directed against both the larval and adult stages of this leafminer. Research is under way to ascertain resistance associated with the immature stages.

Resistance to permethrin has been documented in populations from chrysanthemum or bedding-plant growers in San Diego, Los Angeles, Orange, and Ventura counties. However, because permethrin, methyl parathion, or both are applied to most chrysanthemum crops approximately weekly throughout California, it is unlikely that this resistance is restricted to those few counties.

Studies are in progress on resistance mechanism(s) and the genetic characteristics of resistance development. They will provide information on the potential for cross-resistance to other insecticides as well as an estimation of whether resistance will be long or short term. In general, management of insecticide-resistant leafminers is compatible with integrated pest management. Using control methods other than traditional pesticides, such as insect growth regulators, predators and parasites, and cultural practices, will tend to preserve the effective life of those pesticides.

Implications for other crops

At present, California has a "section 18" emergency registration for the use of permethrin on tomatoes against leafminers and other pests. There is also a "24c" special local needs registration for methamidophos (Monitor) to control leafminers attacking celery. Information from Florida and our study demonstrates that *L. trifolii* is capable of developing resistance to permethrin. Movement of permethrin-resistant flies from greenhouses to nearby vegetable fields makes the spread of resistant traits likely.

Using the methodology outlined previously, we detected only a slight degree of resistance to methamidophos in leafminers from ornamental plants in California (LD_{50} S = 1.68 mg per ml; LD_{50} R = 3.80). This slight tolerance is probably due to cross-resistance induced by selection with methyl parathion, since both insecticides are organophosphates. The response to methamidophos suggests that there are individual leafminers that are intrinsically somewhat resistant. A leafminer population collected from celery in southern Florida is resistant to methamidophos (LD_{50} = 10.84 mg per ml) as compared with the S strain collected in California. The probable cross-resistance, the presence of individuals that are intrinsically resistant, and resistance in another state shipping plant material to California make it highly likely that methamidophos resistance will develop in *L. trifolii* attacking California celery.

A glasshouse crop, such as chrysanthemum, is subject to heavier and more frequent pesticide applications than most field-grown agricultural crops. This situation, together with the confined glasshouse environment, contributes to rapid resistance development. However, there are indications that insecticide-resistant leafminers may not stay limited to ornamental crops in California.

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