

Monitoring insecticide resistance with yellow sticky cards

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The traps can play a key role in insecticide use strategy

The leafminer, a widespread pest of ornamental and vegetable crops, is difficult to control primarily because of biological properties that can lead to the rapid development of resistance to insecticides. We had previously developed a bioassay method for evaluating levels of resistance in the leafminer, *Liriomyza trifolii* (Burgess), but the method requires the use of an insecticide microapplicator, individual handling and treatment of each fly, and maintenance of *L. trifolii* colonies in the laboratory. (See previous discussions of *L. trifolii* and its resistance to insecticides in *California Agriculture* September-October 1981, January-February and September 1984, and July-August 1985.)

Management of leafminer resistance requires knowledge of the insect's capacity to develop resistance. Also, as management strategies are implemented, accurate monitoring of resistance levels is necessary to ensure that susceptibility to registered insecticides is preserved. Furthermore, since resistance is likely to vary from field to field or greenhouse to greenhouse, growers and pest control operators should monitor resistance levels at predetermined sites. Such monitoring requires a simple technique that is accurate, repeatable, and usable in the field or greenhouse.

Yellow sticky cards are effective traps used in monitoring populations of many insect species, such as leafminers, thrips, whiteflies, aphids, and fungus gnats. Although these cards have been recommended as monitoring tools for more than 30 years, they have not been widely used until recently. Strategies have been developed for monitoring leafminer populations with the cards, which now are routinely used by growers, pest control

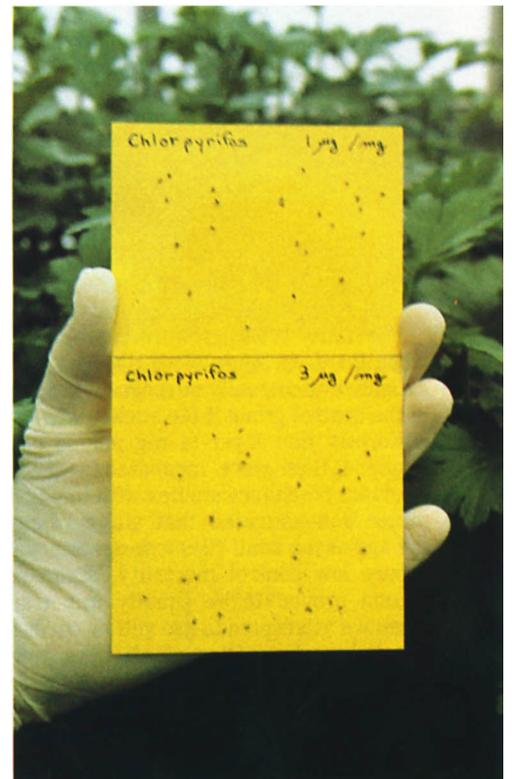
operators, and researchers to monitor populations in diverse crops, such as chrysanthemums, roses, carnations, celery, tomatoes, citrus, and melons.

Resistance monitoring

We tested the use of yellow sticky cards to monitor resistance by incorporating various dosages of a selected insecticide into the sticky material on the cards and then seeing if reproducible dose-mortality relationships could be generated from adult flies caught on the cards. First, we tested the technique with laboratory-reared populations to select the appropriate sticky material, suitable thickness, and best time for evaluation of mortality. Next, we analyzed ways of using the traps for field populations. Possibilities included (1) placing them in the field for a predetermined period to trap insects and then returning them to the laboratory to assess mortality, (2) moving the card by hand through foliage to trap adults, a procedure that would shorten collecting time, or (3) taking infested leaf material to the lab and allowing emerging adults to be caught on traps. Last, we verified the accuracy and reliability of the cards through repeated testing with wild populations and comparing these with a laboratory strain.

Results

After repeated trials with several different polybutene stickers, we selected the material Tangletrap, because it held the flies firmly and was essentially non-toxic to the adults. Then we thoroughly incorporated the insecticides Pounce (permethrin) and Dursban (chlorpyrifos) into the sticker at the desired concentrations and spread them over 3.75- by 6.75-inch



Selected insecticides were incorporated into the sticky material on yellow trap cards to determine dose-response relationships in evaluating insecticide resistance of adult *Liriomyza trifolii* leafminer.



TABLE 1. Resistance of *Liriomyza trifolii* adults from chrysanthemum on yellow sticky cards treated with Dursban (chlorpyrifos)

| Statistics* | Laboratory colony | Field strain | |
|-----------------------|-------------------|--|------------------|
| | | Orange County (Greenhouse I) | San Diego County |
| | | <i>μg formulated insecticide/mg Tangletrap</i> | |
| LC ₅₀ | 1.0 | 10.9 | 13.3 |
| 95% confidence limits | (0.8 - 1.1) | (8.0 - 15.3) | (11.5 - 15.2) |
| LC ₉₀ | 2.2 | 41.0 | 31.4 |
| 95% confidence limits | (1.8 - 3.0) | (26.2 - 91.0) | (25.7 - 42.3) |

*All values corrected for control mortality (< 5%).

TABLE 2. Resistance of *Liriomyza trifolii* adults from chrysanthemum on yellow sticky cards treated with Pounce (permethrin)

| Statistics* | Laboratory colony | Field strain | | | |
|-----------------------|-------------------|--|------------------------------|------------------|-----------------|
| | | Orange County Greenhouse I | Orange County Greenhouse II† | San Diego County | Ventura County‡ |
| | | <i>μg formulated insecticide/mg Tangletrap</i> | | | |
| LC ₅₀ | 1.6 | 58.7 | 1.3 | 46.1 | 3.04 |
| 95% confidence limits | (1.0-2.2) | (41.8-79.5) | (0.8-1.8) | (32.5-74.6) | (2.3-4.1) |
| LC ₉₀ | 7.5 | 145.9 | 6.9 | 226.8 | 6.6 |
| 95% confidence limits | (4.8-19.3) | (102.4-301.2) | (4.8-14.7) | (23.0-727.3) | (4.7-13.3) |

*All values corrected for control mortality (< 8%).

†Collected from *Gerbera*.

‡Collected from celery.

plastic cards. The tests included four to six concentrations of each insecticide.

Mortality readings were reproducible when taken 24 hours after the flies were caught, with virtually no mortality of flies in the control group if the sticker was in a uniformly thin layer (4 mg per sq cm). Trapped flies were incubated at 70°F. Previous resistance studies with this leafminer demonstrated that standardizing the age of the adult flies was necessary to ensure low control mortality. Standardization proved to be equally important when we attempted to use yellow cards in the field, where flies of all ages were caught when traps were left in place for 24 hours or moved through the foliage. Also, unless populations were unusually high, it was difficult to trap enough flies (about 25 per concentration) in a short period of time.

The solution was to assay field flies of known age by collecting leaves infested with leafminer larvae, returning them to the lab, and allowing them to emerge and pupate. Pupae were held in small ventilated vials, and when adults emerged, they had access to honey. When adults were one to two days old, they were released into a small plastic cage and caught on treated cards. Control mortality was acceptable (less than 10 percent) after 24 hours. Using a microscope, we could easily detect flies still alive after 24 hours (showing any sign of leg movement and the like) and conduct standard probit analysis of dose-mortality data.

Resistance levels

Contrasting LC₅₀ values (concentrations of insecticide resulting in 50 percent mortality) for the laboratory colony reared on chrysanthemums versus the Orange County Greenhouse I and San Diego County populations from greenhouse chrysanthemums reveal large differences in the ability of Dursban to kill these leafminers (table 1). We also calculated LC₉₀ values, because they may show signs of resistance before the LC₅₀ values are affected. Both field populations are resistant or are in the process of developing resistance. The laboratory colony consists of flies collected from chrysanthemum crops throughout California but is under no insecticide pressure at UC Riverside. For the intent of this study they were considered to be "susceptible."

The remarkable biological tendency of *L. trifolii* to develop resistance to insecticides is exemplified by its response to Dursban, because this compound was registered for use on chrysanthemum in the summer of 1985. Resistance was suspected after only eight months of use, but in this time over 10 generations of flies could have been exposed to intense selection pressure from frequent applications of this compound. The rate at which this leafminer developed resistance was probably augmented by previous exposure to insecticides in Florida, where the fly originated.

Resistance to Pounce in *L. trifolii* from chrysanthemum in San Diego had been

documented previously (*California Agriculture*, January-February 1984), and this was supported by data from the sticky-card test (table 2). When compared with leafminers from the laboratory colony and populations from Orange County Greenhouse II and Ventura County, the San Diego population is highly resistant to Pounce. Leafminers from the Orange County Greenhouse I location, however, appear to be more resistant to Pounce than any other population tested. This variation within a county emphasizes the need for resistance monitoring at the individual field or greenhouse level. Obviously, the continued use of Pounce at the San Diego and Orange County Greenhouse I locations would no longer be recommended, while this insecticide is still effective at the Orange County Greenhouse II and Ventura County locations. The Ventura County populations were nearly as susceptible as our laboratory colony.

Ongoing studies

The yellow sticky cards coated with insecticide-laced sticker appear to offer a reliable, accurate, and relatively simple way to determine dose-response relationships in evaluating insecticide resistance of adult leafminer. Repeated testing with the laboratory colony provided LC₅₀ values within 95 percent confidence limits of each other (for example, with Pounce, values are 2.2, 1.6, and 2.6). Much more needs to be done, however. The variability in mortality associated with the sexes as well as the relationship between adult and larval resistance must be considered. Also, the relationship between application of insecticides directly to the flies and the sticky trap method must be determined to establish the relative efficiencies of resistance detection by the two techniques.

Information obtained thus far suggests that routine use of yellow sticky traps has tremendous potential and may play a key role in forming an insecticide-use strategy to reduce development of resistance. Creating such a strategy is now a top priority of our research program. Early detection of resistance and monitoring the possibility of a reversion in resistance (that is, a return to susceptibility) should also help to preserve a valuable and diminishing stock of effective insecticides. These approaches should help us cope with the insecticide resistance phenomenon in this leafminer and other important agricultural pests.

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