**Two types of traps were used to monitor leafminers in this study — a corrugated yellow plastic trap one foot square, shown here in an Orange County greenhouse, and a smaller fluorescent yellow cardboard trap. Photo at left shows heavy damage to chrysanthemums caused by *L. trifolii*.**

# Coping with the 'leafminer crisis'

Michael P. Parrella

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Development of insecticide resistance of the leafminer, *Liriomyza trifolii* (Burgess), in chrysanthemum and gerbera greenhouses throughout California has resulted in serious damage. It has been estimated, for example, that California's chrysanthemum industry lost $17 million in 1981. With eventual registration of new insecticides, this "leafminer crisis" should be considerably reduced, but the new materials cannot be viewed as long-term solutions to the problem. Growers must strive to maximize the effective field life of these new compounds by using them only when they are needed. In addition, until these new insecticides gain registration, growers must maximize the efficacy of existing compounds.

Estimating populations of leafminers (both live larvae in leaves and adult flies) is critical to effectively using insecticides. With this in mind, we conducted research to develop efficient sampling plans for live larvae in leaves and for adult flies caught on yellow sticky traps. We used a constant precision sequential sampling plan for two reasons: (1) no "critical level" need be decided in advance, as is commonly required — a very important factor in ornamentals, where damage levels to be tolerated are viewed in light of the crop's overall aesthetic value — and (2) the magnitude of the sampling error is fixed by the decision lines, thus maximizing information while minimizing work.

## Monitoring with yellow traps

Two types of traps were used, a corrugated yellow plastic trap (1 foot square) and a fluorescent yellow cardboard trap, 4½ by 5½ inches. In this article, these will be referred to as large and small traps, respectively.

The traps were suspended just above the chrysanthemums. These could easily be adjusted upward as the crop developed. Traps were lightly sprayed with Tanglefoot after placement in the field. Trials were conducted in 1981 at two chrysanthemum greenhouses in San Diego and Orange counties and continued in 1982 at the Orange County location. Blocks in which the traps were hung were consistent in that all chrysanthemums had been planted no more than four weeks apart. The actual area over which traps were hung varied from greenhouse to greenhouse; normally, these areas were 2,000 to 4,000 square feet. Ten or 20 traps were hung in each block at crop inception and checked weekly for at least 14 weeks. A total of nine blocks were employed where 126 dates were used in calculating the mean number of flies per trap and the variation among these traps. A similar pattern was followed, using the small traps with 11 blocks established in 1983.

## Monitoring for live larvae

A plot was selected in Los Angeles County which consisted of seven varieties of chrysanthemum (Florida Marble, White Marble, Pink Marble, Deep Marble, Accent, Hurricane, and Improved Yellow Hurricane) within a block and replicated three times in a 10,000-square-foot greenhouse. One plant for every 100 plants of a particular variety was sampled in a stratified-random design by selecting three leaves from the top, middle, and bottom strata. The number of live larvae in each leaf was recorded separately. Concurrent research has shown that *L. trifolii* prefers to lay eggs in the middle part of the chrysanthumum plant; thus, this is where larvae can most often be found. A sampling plan was developed based on a three-leaf sample from the center of the plant.

## The sampling plans

The relationship between the variance and the mean for adult flies caught

**Sampling plans and yellow traps developed for chrysanthemums can also be used to forestall serious damage such as this to gerberas. The traps can be easily placed and quickly checked.**

on the large and small traps, as well as for live larvae in leaf samples, was calculated using Iwao's patchiness regression which is the regression of mean crowding:

$$\left(= \text{mean} + \left(\frac{\text{variance}}{\text{mean}}\right) - 1\right)$$

on the mean, and Taylor's power law, which is the regression of log variance on log mean. Both methods provided similar conclusions, with Iwao's method providing a better fit to the sticky trap data, explaining 99 and 97 percent of the variation for the large traps, small traps, respectively. Taylor's method worked best for the live larvae, accounting for 92 percent of the variation. Sampling stop lines were then calculated at the 0.25 percent level of precision.

## Results

The sampling plan developed for large traps is described in table 1. Assume a grower has a 10,000-square-foot greenhouse (all planted within one month) and 10 traps are evenly spaced throughout this area. After the traps are in place for one week, the flies caught on the traps must be counted. For example, the grower counts the total flies on the first trap (assume 55 were counted), then moves to the next trap and counts 65 flies (total: 55 + 65 = 120). The grower proceeds to the third trap and counts 75 flies. The total number of these three traps — 195 flies (55 + 65 + 75) — now exceeds the stop-sampling line which, in table 1, is given by 178 (opposite three traps counted). The mean number of flies per trap can now be estimated by dividing the total number of flies by the number of traps counted. Thus, a reliable estimate can be made of the mean number of flies on all traps by counting only three of the traps. The amount of time saved can be considerable. It is important that traps be uniformly spaced throughout the crop, avoiding deliberate placement near doors, vents, or over especially sensitive varieties. This would bias population estimates and invalidate the variance-to-mean relationship on which the sampling plan is based.

A similar scheme has been followed for sampling live larvae (table 2). With larval counts, higher populations will usually be encountered on specific varieties and in the marginal plants in the beds. Therefore, it is important to sample leaves from all parts of the beds and from all varieties.

## Usefulness in greenhouse

Yellow sticky traps are available from many commercial sources and should be used by growers or pest control advisors (PCAs) to monitor adult fly populations in chrysanthemum or gerbera greenhouses. A gerbera greenhouse with plants in pots or grown for cut flowers usually satisfies the requirement of plant homogeneity, which is necessary when using yellow traps. Therefore, we believe that the sampling plans developed can be employed in a gerbera house.

Yellow traps can be easily placed in greenhouses and are subject to rapid visual assessment after one week. Ease of handling and assessment make them preferred over other, more conventional sampling techniques (sweep net, pupal

**TABLE 1. Sequential sampling chart for *Liriomyza trifolii* adults caught weekly on yellow traps at 0.25 level of precision**

| | | | Large trap | Small trap |
|---|---|---|---|---|
| Traps counted | Weekly trap catch | Cumulative weekly catch | Stop counting if cumulative weekly count exceeds: | Stop counting if cumulative weekly count exceeds: |
| 1 | 55 | 55 | — | — |
| 2 | 65 | 120 | 317 | 329 |
| 3 | + 75 | 195* | 178 | 207 |
| | 195 | | | |
| 4 | | | 140 | 167 |
| 5 | | | 119 | 144 |
| 6 | | | 104 | 127 |
| 7 | 195/3 = 65 flies/trap | | 93 | 114 |
| 8 | | | 84 | 103 |
| 9 | | | 75 | 92 |
| 10 | | | 67 | 83 |
| 11 | | | 59 | 74 |
| 12 | | | 57 | 65 |
| 13 | | | 45 | 56 |
| 14 | | | 38 | 48 |
| 15 | | | 32 | 40 |

*A reliable estimate of the mean number of flies per trap can be found by dividing the cumulative number of flies by the number of traps sampled.

**TABLE 2. Sequential sampling chart for *Liriomyza trifolii* larvae at 0.25 level of precision**

| | | | All varieties |
|---|---|---|---|
| Plants sampled | Total larval count | Cumulative larval count | Stop counting if cumulative larval count exceeds: |
| 1 | 15 | 15 | 60 |
| 2 | 10 | 25 | 51 |
| 3 | 7 | 32 | 47 |
| 4 | +20 | 52* | 43 |
| | 52 | | |
| 5 | | | 41 |
| 6 | $\frac{52}{(3\times4)} = 4.3\ \frac{\text{larvae}}{\text{leaf}}$ | | 39 |
| 7 | | | 38 |
| 8 | | | 37 |
| 9 | | | 36 |
| 10 | | | 35 |
| 11 | | | 34 |
| 12 | | | 33 |
| 13 | | | 33 |
| 14 | | | 32 |
| 15 | | | 32 |

*A reliable estimate of the mean number of larvae per leaf can be found by dividing the cumulative number of larvae by 3 times the number of plants sampled.

trays, etc.). The sampling plan presented here adds even more flexibility to the yellow trap as a sampling tool by decreasing the time needed to make counts. In some instances, of course, all traps may have to be counted (when no "stop" is reached). However, time usually will be saved when the sampling plan is used through total crop development. By evenly spacing traps throughout a homogeneous crop of chrysanthemums or gerberas, growers will obtain an areawide view of population changes. Having just one trap in the center of an area would provide an inaccurate reflection of adult flies present. The additional work of counting more traps can be offset somewhat by using the sampling scheme presented here.

Yellow traps to monitor adult flies provide the grower or PCA with a rapid assessment of what the population is doing in each specific greenhouse or crop area. Thus, the need to forecast treatments or to determine their effectiveness can be satisfied. Such data are vital to proper use of insecticides to control *L. trifolii*. With an ornamental crop such as chrysanthemums, knowing when to treat is extremely important. However, with a fly able to develop insecticide resistance, such as *L. trifolii*, knowing when not to treat may be just as important.

The sampling plan for live larvae (table 2) can be used as outlined here for yellow sticky traps and can yield the following additional information: knowing when to treat (numerous live larvae indicate future adult populations); knowing when not to treat (or if no larvae are found, fogging the greenhouse with insecticide directed only at adults [based on yellow trap counts] instead of a thorough wet spray); and assessing the efficacy of pesticide treatments. Finally, if parasites are being used for leafminer control, leaf samples provide data on parasite efficacy, in addition to indicating that more parasite releases are needed.

With an aesthetic value crop such as chrysanthemum, it is very difficult to establish the population level at which the grower must treat. The economic threshold varies from grower to grower and fluctuates during the year as crop value changes due to the public's association of flowers with specific holidays, such as Mother's Day and Easter. Reliable estimates of leafminer populations in chrysanthemum greenhouses will aid the grower in making treatment decisions by accurately gauging population increases or decreases.

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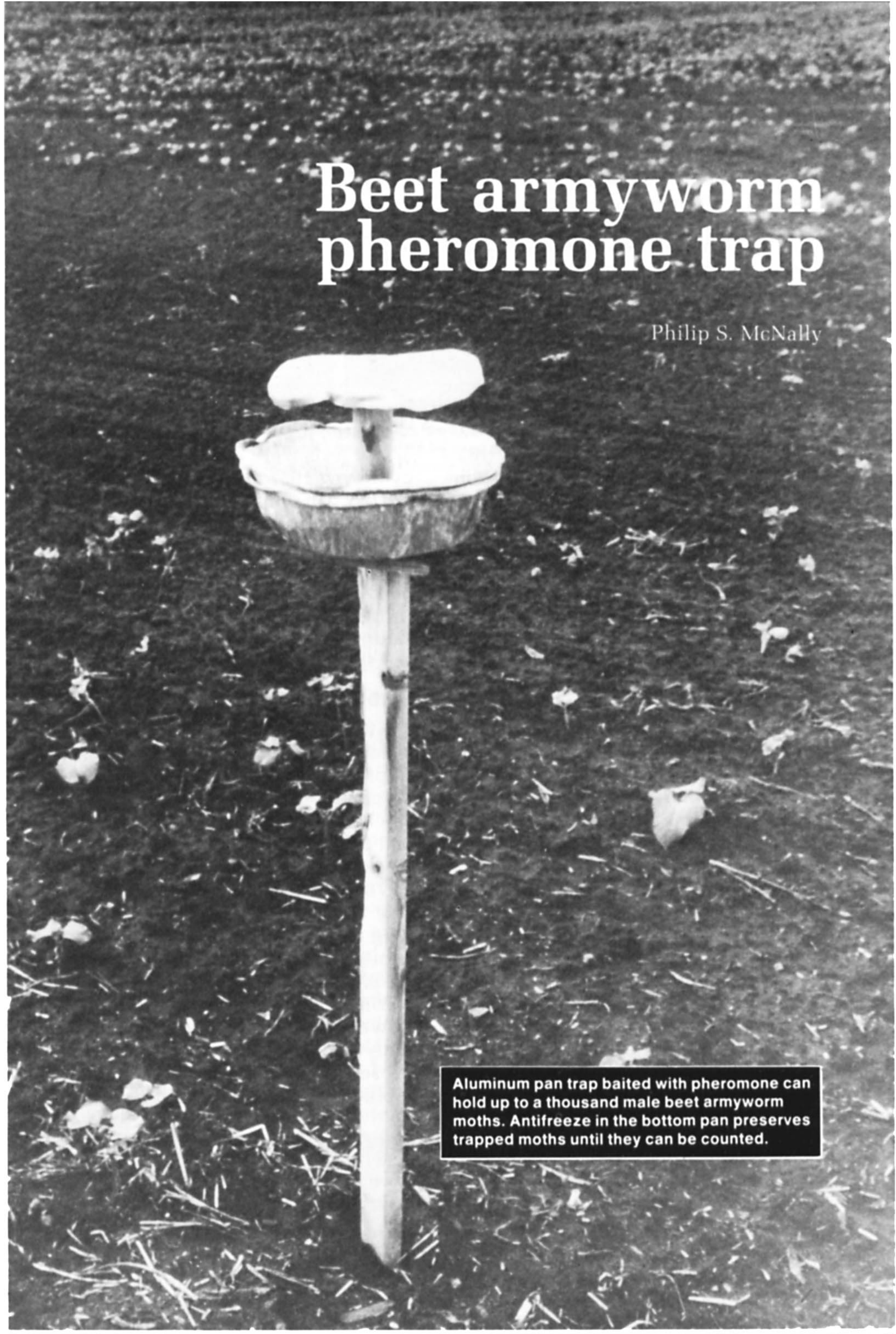
# Beet armyworm pheromone trap

Philip S. McNally



**Aluminum pan trap baited with pheromone can hold up to a thousand male beet armyworm moths. Antifreeze in the bottom pan preserves trapped moths until they can be counted.**

## *Of three types tested, a liquid trap was the most practical and effective*

Monitoring the beet armyworm, a destructive pest of tomatoes, alfalfa, cotton, sugarbeets, and other crops, consists of time-consuming visual searches of foliage and fruit for eggs and larvae. Use of pheromone traps can help indicate the numbers of this insect, *Spodoptera exigua* (Hübner), in the field at a particular time.

After a sex pheromone blend from female beet armyworms was isolated and identified in 1981, a study was conducted during 1981 and 1982 in Tracy to find a suitable beet armyworm pheromone trap and to evaluate the longevity of the pheromone substrate under California field conditions.