RESPONSE OF THREE POPULATIONS OF  
*LIRIOMYZA TRIFOLII* (DIPTERA:AGROMYZIDAE)  
TO TOPICAL APPLICATIONS OF PERMETHRIN  
AND BIFENTHRIN  

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ABSTRACT  
Susceptibility to the pyrethroid insecticides permethrin and bifenthrin was determined for three populations of *Liriomyza trifolii* (Burgess) originally collected from commercial chrysanthemums in California, Florida, and Maryland. The Maryland population was significantly more resistant to both compounds than either the California or Florida population. Susceptibilities may have been affected by the number of generations populations were maintained as laboratory colonies.

RESUMEN  
Susceptibilidad a los insecticidas piretroides permethrin y bifenthrin fue determinada en tres poblaciones de *Liriomyza trifolii* (Burgess) colectadas originalmente de crisantemos comerciales en California, Florida, y Maryland. La población colectada en Maryland fue significativamente más resistente a ambos productos que la población de California o Florida. Susceptibilidades pudieron haber sido afectadas por el número de generaciones cuando fueron mantenidas como colonias en el laboratorio.

*Liriomyza trifolii* (Burgess) is a highly polyphagous leafminer reported to attack at least 120 plant species in 21 families (Minkenberg & van Lenteren 1986) and is one of the most pests of chrysanthemums (Poe & Montz 1981), celery (Leibee 1984, Trumble 1981) and tomatoes (Schuster & Everett 1983) in North America. Unjudicious use of insecticides resulting in resistance, and the species’ exceptional reproductive capabilities are two major reasons for this leafminer's recent rise to major pest status (Parrella & Keil 1984).

Failure of insecticides such as pyrethroids and organophosphates to control *L. trifolii* on chrysanthemums has prompted several studies involving the effectiveness of these and other compounds. Parrella et al. (1982) determined the efficacy of 12 insecticides against leafminer larvae on chrysanthemums. Alverson & Gorsuch (1982) found that the performance of permethrin, cypermethrin, methyl parathion, and methamidophos were significantly enhanced when applied to resistant chrysanthemum cultivars. Sublethal doses of insect growth regulators applied to *L. trifolii* larvae significantly decreased fecundity of resulting adults (Robb & Parrella 1984) and foliar sprays of permethrin and methyl parathion applied to chrysanthemums significantly reduced feeding and oviposition by adult leafminers (Hobb & Parrella 1985).

Susceptibility of *L. trifolii* populations from different locations is likely to vary with the frequency of insecticide applications made to control them. Keil et al. (1985) and Haynes et al. (1986) determined that resistance to permethrin varied among ornamental

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greenhouse populations located in different southern California counties, and even within a county (Haynes et al. 1986). Significant differences in susceptibility to permethrin and fenvalerate were found for *L. trifolii* and *L. sativae* Blanchard (a similar species) from agricultural sites in Hawaii with histories of different insecticide usage (Mason et al. 1987).

Comparison of resistance levels of populations from different regions using dosage-mortality data may aid in understanding how varying patterns of insecticide usage affect the development of resistance. These data may also be useful when developing a pest management program in a region where the pest has recently been introduced. *L. trifolii* has been established accidentally by man in previously unaffected areas and the insecticide susceptibility of these introduced populations was probably affected by the prior insecticide usage in the region of origin (Parrella & Keil 1984).

The objective of this study was to compare the relative susceptibilities of *L. trifolii* from widely-separated geographic locations. Populations from California, Florida, and Maryland were tested using the widely-applied pyrethroid insecticide permethrin and bifenthrin, a material which has been used for leafminer control for only ca. two years.

**Materials and Methods**

*Colonies of L. trifolii* were established using pupae from colonies originating from commercial greenhouses in southern California (CA) and southwestern Florida (FL) and infested foliage collected from greenhouses in northeastern Maryland (MD). The CA and FL colonies were initiated with ca. 500 pupae each and the MD colony was initiated with ca. 400 pupae reared from foliage.

At Virginia Polytechnic Institute and State University colonies were maintained on chrysanthemums (Manatee Iceberg var.) at three separate locations (buildings) to ensure that crossbreeding between populations could not occur. Adult *L. trifolii* that emerged were contained in 24 by 24 by 24 cm plexiglass and screen cages. Nutrient sources included both honey water smeared on the screen and 5 cm diameter sponges soaked with a 10% sucrose solution and held in aluminum weighing boats.

For topical application, females < 3 d old were aspirated directly from the cages into 148 ml polystyrene vials, 15 flies per vial. The vials were fitted with polyethylene caps with screened holes. The screen was lightly streaked with honey. Before application of insecticide, the flies were anesthetized within the vials with CO2 for 60 s.

*Insecticide* formulations were applied to individual flies with a microapplicator (Instrumentation Specialties Co., Lincoln, NB) equipped with a 1-ml syringe and a 27-gauge cannula. The microapplicator was calibrated to deliver 0.6 microliter of formulation, a delivery rate determined optimal for topical application to individual adult *L. trifolii* (Keil et al. 1985). Technical permethrin (FMC Corp., 94.3% pure) and bifenthrin (FMC Corp., 96.0% pure) were dissolved in nanograde acetone.

Anesthetized flies were transferred to a 9 cm diameter sheet of filter paper mounted on an index card. One drop was placed upon the thorax of each fly. Flies adhering to the drop at the tip of the cannula were removed with a camel’s hair brush which was dipped in acetone between uses. After all flies from one vial had been treated, they were transferred with an aspirator to a holding unit for recovery. The holding unit, similar to that used by Keil et al. (1985), consisted of an inverted 148 ml polystyrene vial with a screen bottom streaked with honey, mounted to another vial via their caps. A chrysanthemum leaf was placed in the top vial with its stem extending through holes in the caps into the bottom vial which contained water. Cotton was used to plug the hole around the leaf stem.

Four replications consisting of 15 female flies each were tested for each concentration. Preliminary studies determined concentrations to be tested for each population.
Concentrations of 0.08, 0.1, 0.2, 0.4, and 0.6 mg/ml for the CA and FL populations and 1.0, 2.0, 4.0, 6.0 and 8.0 mg/ml for the MD population were used for permethrin. Bifenthrin treatment concentrations were 0.02, 0.04, 0.06, 0.08, and 0.1 mg/ml for the CA and FL populations and 0.2, 0.4, 0.8, 1.0, and 2.0 mg/ml for the MD population. A solvent control was used for each insecticide. After application, holding units containing the flies were maintained at 25°C, 14:10 LD photoperiod and a RH of ca. 50%. Mortality was assessed at 24 h. Death was usually readily apparent. Individuals appearing disoriented and unable to walk or fly were counted as dead. Flies exhibiting such behavior in preliminary studies did not recover.

Data were analyzed using the SAS PROC PROBIT and PROC REG procedures (SAS Institute Inc. 1985). LD_{50} values were considered significantly different if the 95% fiducial limits did not overlap.

RESULTS AND DISCUSSION

This method of evaluating insecticide toxicity against adult *Liriomyza* developed by Keil et al. (1985) proved consistent in our preliminary and final studies. Control (acetone application) mortality ranged from 0-6.6%.

Comparison of probit statistics of the three populations to permethrin (Figure 1 and Table 1) and bifenthrin (Figure 2 and Table 1) indicate that the *L. trifolii* colony originating from MD was significantly more resistant than those originating from CA and FL. A greater than 33-fold difference in the LD_{50} values for permethrin was found between the MD (LD_{50} = 3.35 mg/ml) and FL (LD_{50} = 0.10 mg/ml) populations. The LD_{50} values for the CA and FL populations lie between those found for a laboratory-selected highly permethrin-susceptible strain of *L. trifolii* and a field-collected putative susceptible strain evaluated by Keil et al. (1985). The MD value is slightly less than that determined for a field-collected permethrin-resistant strain (Keil et al. 1985).

Although these results may indicate a greater insecticide usage, particularly of pyrethroids, in the MD greenhouses where leafminers were originally collected, the

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**Fig. 1.** Dosage-mortality lines for adult *L. trifolii* females treated with technical permethrin in acetone. CA, southern California; FL, southwestern Florida; MD, northeastern Maryland.
TABLE 1. PROBIT ANALYSIS STATISTICS FOR THREE *L. trifolii* POPULATIONS TREATED WITH TECHNICAL PERMETHRIN AND BIFENTHRIN DISSOLVED IN ACETONE.

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Populationa</th>
<th>LD$_{50}$ (mg/ml)</th>
<th>95% Fiducial limits</th>
<th>Slope</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permethrin</td>
<td>CA</td>
<td>0.14</td>
<td>0.11-0.16</td>
<td>1.90</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>FL</td>
<td>0.10</td>
<td>0.05-0.15</td>
<td>0.94</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>MD</td>
<td>3.35</td>
<td>2.92-3.83</td>
<td>2.76</td>
<td>0.33</td>
</tr>
<tr>
<td>Bifenthrin</td>
<td>CA</td>
<td>0.05</td>
<td>0.04-0.06</td>
<td>1.77</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>FL</td>
<td>0.06</td>
<td>0.04-0.12</td>
<td>2.10</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>MD</td>
<td>0.77</td>
<td>0.66-0.90</td>
<td>2.31</td>
<td>0.29</td>
</tr>
</tbody>
</table>

*CA, southern California; FL, southwestern Florida; MD, northeastern Maryland.

number of generations the populations were maintained in the laboratory may also have affected susceptibility to the compounds tested. The FL and CA populations were obtained for our studies from colonies which had been maintained for several generations in the laboratory with occasional input of wild stock. Our MD colony, however, was initiated with individuals collected as larvae directly from greenhouses and, therefore, more recently exposed to selection pressure by insecticides. A 50% decrease in resistance has been observed for a field-collected *L. trifolii* population after being maintained in the laboratory for three months (ca. 5 generations) in the absence of insecticide selection pressure (M. P. Parrella, UC, Riverside, unpublished data).

Insecticide treatments in the ten months prior to collection of larvae in the MD greenhouses included applications of the pyrethroids fluvalinate and permethrin and apparently selected for a relatively highly pyrethroid-resistant strain of *L. trifolii*. Former use of chlorinated hydrocarbon insecticides, some reported to cause cross resist-

![Dosage-mortality lines for adult *L. trifolii* females treated with technical bifenthrin in acetone. CA, southern California; FL, southwestern Florida; MD, northeastern Maryland.](image-url)
ance to pyrethroids (Farnham & Sawicki 1976), may also have affected this population's susceptibility to the pyrethroids tested.

Although bifenthrin has been in use for a relatively short period of time, resistance has apparently already developed for it in L. trifolii. This development illustrates how prior widespread use (and misuse) of certain insecticides can adversely affect the performance of a similar, yet more recently introduced, compound.

ACKNOWLEDGEMENT

The authors wish to thank J. L. Eaton, H. G. Larew, and L. T. Kok for reviewing the manuscript, M. P. Parrella (UC, Riverside), D. L. Warkentin (Yoder Bros., Alva, FL), and H. G. Larew (USDA, Beltsville) for providing the L. trifolii colonies, and E. Martínez for providing the Spanish abstract. Chrysanthemum plants were donated by Yoder Bros., Inc., Barberton, OH. This research was supported by BARD grant US 707-83.

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