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RESPONSE OF TWOSPOTTED SPIDER MITES, LEAFMINERS AND THEIR PARASITOIDS AND OTHER ARTHROPODS TO NEWLY DEVELOPED PESTICIDES IN CHRYSANTHEMUMS[1]

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Abstract. **Experiments were conducted in the spring and fall of 1980 to evaluate the responses of arthropod populations of 'Manatee Iceberg' chrysanthemums** (Chrysanthemum x morifolium **Ramat.) to experimental and presently used pesticides. Foliar spray applications of Afugan, Bolstar, Ficam, Penncap-M, Ambush, Vydate, Vendex and DPX 3792 (2-(acetyloxy)-3-dodecyl-1,4-naphthalenedione) were evaluated in the spring. After 2 applications, the fewest twospotted spider mites** (Tetranychus urticae **Koch) were found on leaves treated with Mavrik. The fewest** Liriomyza trifolii **Burgess leafmines at harvest were found on leaves treated with Vydate; Vydate in combination with Ambush, Bolstar or Mavrik; or treated with Penncap-M. In the fall, Dursban, Mavrik, Vendex, Altosid SR-10, Penncap-M, Vydate and UC 55248 (3-(2-ethylhexanoyloxy)-5,5-dimethyl-2-(2'-methylphenyl)-2-cyclohexen-1-one) were similarly evaluated. Four days after the first applications, the lowest numbers of spider mites were found on chrysanthemums treated with Mavrik, Vendex with Nu-Film 17, Vydate, Vydate with Ambush, and Ambush alone. The lowest rates of parasitism of leafminers by hymenopterans occurred in plots treated with Dursban and the highest rates occurred in plots treated with UC 55248 or Altosid SR-10. Foliar phytotoxicity developed on plants treated with Vydate and Bolstar. No treatment resulted in phytotoxicity of flowers.**

New pesticidal compounds are developed periodically that may be useful in the management of pests in Florida's pompon chrysanthemum (*Chrysanthemum* x *morifolium* Ramat.) industry. Pesticides applied for control of one pest may alter the status of other pests or beneficial arthropods (1, 2). In gypsophila (*Gypsophila paniculata* L.), methomyl applied several times, although resulting in effective control of pest Lepidoptera, may cause an increase in *Liriomyza* leafminers and twospotted spider mites (*Tetranychus urticae* Koch) (Price, unpublished data). Thus, it is important to understand the impact that the use of new compounds has on the total arthropod community *within* chrysanthemums.

The fall and spring 1980 experiments reported herein were performed to determine the effects of 9 newly developed pesticides on arthropods inhabiting chrysanthemums at the Bradenton Agricultural Research & Education Center in 1980. Pesticides currently used in the pompon industry were included in the experiments for comparison.

Materials and Methods

Experiment 1—Spring 1980

This experiment was performed in a saran shadehouse which provided 25% light reduction. Rooted cuttings of 'Manatee Iceberg' chrysanthemums were planted in fumigated, ground beds amended with superphosphate with fritted trace elements at 630 lb/acre (708 kg/ha). Plants were set on February 19, 1980 and incandescent light was provided to the crop nightly from 10:00 PM until 2:00 AM until March 16. Stems were pinched to 5 nodes on March 6. Water was provided to the crop by trickle irrigation (3 tubes per bed) and natural rainfall. No fungicides were applied and Lannate (methomyl) 90 SP at 0.5 lb/100 gal (0.7 g/liter) was sprayed to wet all foliage on March 31, April 7, 21 and 28. Experimental plots consisted of 18 plants (ca. 90 stems) spaced in 3 rows of 6 plants each across a bed. Plots were separated by 2 unplanted and 1 planted row across the bed. Treatments were replicated 4 times in randomized complete blocks and were applied on May 2, 11, 16, 23 and 30.

Experimental pesticides were applied at 225 gal/acre (2105 liter/ha) in a hand-held, 2.5 gal (9.5 liter), CO_2 propelled sprayer maintained at 40 psi (2.8 kg/cm^2) with a wand and adjustable cone nozzle. The newly developed compounds tested were: a powdery mildew fungicide (Afugan 30% EC), an organophosphorous insecticide (Bolstar 6 EC), an insecticide used for household pest control (Ficam 76 WP), a synthetic pyrethroid insecticide (Mavrik 2 EC), an experimental 4 EC formulation of Vendex miticide and the experimental miticide, DPX 3792 (2-(acetyloxy)-3-dodecyl-1,4-naphthalenedione) 25 WP. Currently registered pesticides tested were a microencapsulated leafminer control material (Penncap-M 2F), a leafminer and mite control compound (Vydate 2L), and Vendex 50 WP miticide. The common names of the pesticides tested and the concentrations used appear in Table 1.

Ten leaves per plot were selected at random from all the fully expanded leaves on May 15 and June 2. The average numbers of twospotted spider mites per leaf were determined by using the leaf brushing method described by Price *et al.* (3). Numbers of green peach aphids (*Myzus persicae* (Sulzer)) and nymphal flower thrips (*Frankliniella cephalica* (Crawford)) per flower were determined from samples of 10 flowers harvested on June 2. Densities of insects within the flowers were determined through the wash and filtration method described by Price (4). Numbers

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Table 1. Number of arthropods recorded from 'Manatee Iceberg' chrysanthemums treated with various pesticides (Experiment 1—Spring 1980).

Treatment				No./open flower June 2		Spider mites/leaf		Leafmines/ stem
Common name	Trade name	Formulation	Amt. Prod/ 100 gal.	Thrips nymphs	Aphids	May 15	June 2	June 2
Untreated check				32.95 a[z]	0.98 a	5.75 bcd	16.75 ab	19.10 a
Pyrazophos	Afugan	30% EC	2.5 pt.	1.88 c	0.18 b	12.25 ab	26.00 a	3.85 de
Permethrin	Ambush	2 EC	0.5 pt.	16.15 bc	0.25 b	4.50 cd	7.00 cd	7.92 cd
Sulprofos	Bolstar	6 EC	1.33 pt.	0.75 c	0.30 b	3.25 cd	11.75 bc	2.44 de
Bendiocarb	Ficam	76 WP	1.25 pt.	0.95 c	0.08 b	12.50 a	19.50 ab	14.77 ab
Fluvalinate	Mavrik	2 EC	0.5 pt.	4.10 c	0.05 b	0.75 d	0.25 f	9.63 bc
Methyl parathion	Penncap-M	2 F	2.0 pt.	0.70 c	0.13 b	12.00 ab	20.50 ab	7.10 cde
Oxamyl	Vydate	2 L	4.0 pt.	0.35 c	0.10 b	3.00 cd	8.25 cd	1.83 e
Oxamyl + permethrin	Vydate + Ambush	2 L 2 EC	4.0 pt. + 0.5 pt.	0.45 c	0.00 b	3.50 cd	0.75 f	1.79 e
Oxamyl + sulprofos	Vydate + Bolstar	2 L 6 EC	4.0 pt. + 1.33 pt.	1.75 c	0.00 b	4.00 cd	1.00 f	1.35 e
Oxamyl + fluvalinate	Vydate + Mavrik	2 L 2 EC	4.0 pt. + 0.5 pt.	0.33 c	0.00 b	2.50 cd	0.00 f	1.79 e
Oxamyl + methyl parathion	Vydate + Penncap-M	2 L 2 F	4.0 pt. + 2.0 pt.	0.88 c	0.03 b	7.75 abc	5.00 de	2.37 de
DPX 3792[y]		25 WP	2 lb.	27.73 ab	0.25 b	6.75 a-d	1.00 f	16.73 a
Hexakis	Vendex	50 WP	1 lb.	34.05 a	1.10 a	6.5 bcd	7.25 cde	14.94 ab
Hexakis	Vendex	4 EC	1 pt.	30.98 ab	0.80 a	4.75 cd	2.50 ef	15.79 a

[z]Values within columns followed by the same letter are not significantly different ($p \geqq .05$) by Duncan's New Multiple Range Test.
[y]2-(acetyloxy)-3-dodecyl-1,4-naphthalenedione.

of *Liriomyza trifolii* Burgess leafmines per stem were determined on June 2 by counting all the mines in leaves of 1 stem per plant from all plants in 2 rows across the bed. The crop was harvested and phytotoxicity evaluations were made on June 2.

Experiment 2—Fall 1980

This experiment was designed and performed similarly to the previous experiment. Plants were set on August 29 and lights were operated until September 29. Chrysanthemums were pinched on September 8 and maintenance sprays of a tank-mix of Lannate 90 SP at 0.5 lb/100 gal. plus Manzate 200 (mancozeb) 80 WP at 0.5 lb/100 gal. plus Captan 50 WP at 1 lb/100 gal. (1.2 g/liter) were applied to wet all leaves on September 22, October 3 and 10.

Experimental plots were designed as before except that each plot from the middle of the bed to one side was planted with 'Manatee Iceberg' and the other side was planted with 'Yellow Show Off' chrysanthemums. One entire side of a bed was a single cultivar assigned by a random process.

Five newly developed compounds or new formulations of previously developed compounds, applied at 1x, 2x and 4x (1x, 2.5x and 5x for Altosid SR-10) rates were included as experimental treatments as follows: an experimental 25 WP formulation of an organophosphorous insecticide (Dursban), Mavrik 2 EC and 20 WP, an insect growth regulator (Altosid SR-10 10 WP), and an experimental miticide (UC 55248 (3-(2-ethylhexanoyloxy)-5,5-dimethyl-2-(2'-methylphenyl)-2-cyclohexen-1-one) 4 EC). Also included as treatments were Vendex 50 WP alone and with Nu-Film 17 spray adjuvant, Vydate 2L at a 1x rate, Ambush 2 EC at a 1x rate and a tank-mix of 0.5x rates of Vydate 2L and Ambush 2 EC. Common names and concentrations of all compounds tested appear in Table 2.

Altosid SR-10 treatments were applied over the plants and onto the soil with a watering can at a rate of 500 gal/acre (4,210 liters/ha). All other treatments were applied as foliar sprays in the manner of the spring experiment. Applications of each pesticide were made on October 24 and 31, November 7, 14 and 21 and December 1.

Samples taken to determine arthropod densities were from 'Manatee Iceberg' plants only. Phytotoxicity evaluations were made on both cultivars 3 days after the 5th application of experimental treatments.

The spirea aphid (*Aphis citricola* v.d. Goot) was the only aphid abundant during the fall season. Densities of this insect were determined on October 28 by counting all the flower peduncles upon which 1 or more of the aphids were found.

Twenty-five leaves were selected randomly from the 3 'Manatee Iceberg' plants growing nearest the middle of each plot on November 19 for leafminers and their parasitoids. Leaves were placed in a 1 qt (946.5 ml), cylindrical ice cream carton which was stored in a rearing room maintained at ca 80 ± 2°F to permit leafminers and their hymenopterous parasitoids (*Chrysonotomyia* spp. including *C. formosa* Westwood (Eulophidae), *Diglyphus intermedius* Girault (Eulophidae) and *Opius dimidiatus* (Ashmead) (Braconidae)) to develop to the adult stage. Five weeks later all leafminers and their parasitoids were counted. The parasitoids collected were species which usually develop no more than 1 parasitoid per leafminer host. Thus "% parasitism" was calculated by the formula:

$$\% \text{ parasitism} = \frac{100 \times \text{no. adult parasitoids}}{\text{no. adult parasitoids} + \text{no. adult leafminers}}$$

Twenty-five leaves per plot were selected at random on December 9 to determine the mean number of leafminers per leaf. Numbers of twospotted spider mites per leaf were determined on October 28 and on November 20 from samples of 10 leaves by the leaf brushing method used in the spring experiment.

Results and Discussion

Experiment 1—Spring 1980

Populations of twospotted spider mites, flower thrips and *L. trifolii* leafminers reached levels which would require control commercially. Results of pesticides' effects on these pests and the green peach aphid are reported in Table 1.

Flower thrips nymphs. The highest numbers of nymphal thrips per flower were found in untreated plots and plots treated with DPX 3792 or Vendex. An intermediate number of thrips was found in plots treated with Ambush. All other treatments resulted in excellent control.

Table 2. Numbers of arthropods recorded from 'Manatee Iceberg' chrysanthemums treated with various pesticides (Experiment 2—Fall 1980).

Treatment				No. peduncles w/aphids	No. spider mites/leaf		Leafmines/ leaf	Adults reared from 25 leaves sampled Nov. 19		
Common name	Trade name	Formulation	Amt. prod./ 100 gal.	Oct. 28	Oct. 28	Nov. 20	Dec. 9	Leafminers	Parasitoids	% parasitism
Water check	—	—	—	10.00 ab[z]	37.25 ab	24.75 ab	1.20 c-f	19.75 b-e	4.25 cde	19.96 abc
Unsprayed check	—	—	—	8.75 abc	36.00 ab	30.75 a	1.99 bc	28.25 bc	8.50 bc	24.57 abc
chlorpyrifos	Dursban	25 WP	1 lb.	0.00 f	44.75 a	18.00 a-d	1.69 cde	18.25 b-e	0.75 ef	2.87 ef
chlorpyrifos	Dursban	25 WP	2 lb.	0.00 f	16.00 cd	6.75 c-f	1.85 bcd	22.75 b-e	0.25 f	1.09 f
chlorpyrifos	Dursban	25 WP	4 lb.	0.00 f	16.75 cd	5.00 efg	1.27 cde	2.75 de	0.00 f	
fluvalinate	Mavrik	2 EC	0.25 pt.	0.25 f	6.25 d	0.50 fg	1.56 cde	12.00 cde	2.50 def	19.01 bcd
fluvalinate	Mavrik	2 EC	0.5 pt.	0.00 f	7.00 d	0.00 g	1.11 c-g	13.25 cde	0.75 ef	4.41 ef
fluvalinate	Mavrik	2 EC	1.0 pt.	0.00 f	2.75 d	1.25 fg	0.76 d-g	8.75 cde	1.50 ef	15.00 cde
fluvalinate	Mavrik	20 WP	0.31 lb.	0.75 ef	6.25 d	3.50 efg	1.72 cd	20.25 b-e	6.50 bcd	24.34 abc
fluvalinate	Mavrik	20 WP	0.62 lb.	0.25 f	5.50 d	3.25 efg	1.39 cde	17.25 b-e	3.25 def	16.13 cde
fluvalinate	Mavrik	20 WP	1.25 lb.	0.00 f	9.50 d	1.25 efg	1.77 bcd	7.75 cde	2.75 def	26.52 abc
hexakis	Vendex	50 WP	1 lb.	2.25 def	16.75 cd	5.75 d-g	1.90 bc	22.25 b-e	9.00 bc	29.80 abc
hexakis + pinolene	Vendex + Nu-Film 17	50 WP	1 lb. + 2.25 pt.	4.50 cde	7.25 d	4.25 efg	1.76 bcd	22.75 b-e	12.26 b	33.80 abc
methoprene	Altosid SR-10	10 WP	1 lb.	12.25 a	43.00 a	21.50 abc	1.37 cde	26.75 bc	7.50 bcd	20.80 bc
methoprene	Altosid SR-10	10 WP	2.5 lb.	13.50 a	52.50 a	23.25 ab	1.45 cde	22.75 b-e	11.00 b	43.30 ab
methoprene	Altosid SR-10	10 WP	5.0 lb.	13.00 a	31.25 abc	22.25 abc	1.62 cde	25.00 bcd	12.50 b	40.55 ab
methyl parathion	Penncap-M	2 F	1 qt.	0.00 f	20.25 bcd	11.00 b-e	0.86 d-g	11.25 cde	1.25 ef	6.02 def
oxamyl	Vydate	2 L	4 qt.	0.00 f	3.75 d	0.50 fg	0.09 g	0.00 e	0.00 f	
oxamyl + permethrin	Vydate + Ambush	2 L + 2 EC	2 pt. + 0.25 pt.	0.00 f	2.00 d	1.75 efg	0.21 fg	1.00 e	0.00 f	
permethrin	Ambush	2 EC	0.5 pt.	0.00 f	9.25 d	0.50 fg	0.62 efg	3.25 de	0.50 f	
UC 55248[y]		4 EC	0.25 qt.	10.25 abc	17.50 cd	1.00 fg	3.59 a	52.00 a	38.00 a	43.29 ab
UC 55248		4 EC	0.50 qt.	5.25 bcd	14.25 d	4.00 efg	3.01 a	51.00 a	38.00 a	47.21 a
UC 55248		4 EC	1 qt.	5.25 bcd	7.75 d	1.00 fg	2.77 ab	37.50 ab	12.00 bc	21.63 abc

[z]Values within columns followed by the same letter are not significantly different ($p \leq .05$) by Duncan's New Multiple Range Test.
[y]3-(2-ethylhexanoyloxy)-5,5-dimethyl-2-(2′-methylphenyl)-2-cyclohexen-1-one.

Green peach aphids. Numbers of green peach aphids per flower were low in plots of all treatments. However, the highest numbers among all plots occurred in flowers to which no pesticides were applied or flowers treated with either formulation of Vendex.

Twospotted spider mites. Spider mite populations were more dense on leaves treated with Afugan, Ficam, Penncap-M alone, Penncap-M with Vydate and DPX 3792 than on leaves treated with any other pesticide 2 days after the 2nd application. Mite densities were lower at that time in untreated plots and in plots treated with Ambush, Bolstar, Mavrik, all treatments containing Vydate (except Vydate with Penncap-M), DPX 3792 and both formulations of Vendex. Three days after the 5th application of experimental treatments, the greatest numbers of mites were found in untreated plots and in plots treated with Afugan, Ficam and Penncap-M. Also on the latter date, the lowest numbers of mites were found on chrysanthemums treated with Mavrik; Vydate in combination with Ambush, Bolstar or Mavrik; and on those treated with DPX 3792 and Vendex 4 EC.

L. trifolii leafmines. Numbers of leafmines per stem were greatest in chrysanthemums from the untreated check, Ficam, DPX 3792 and Vendex plots. The lowest densities of leafmines occurred in chrysanthemums to which Afugan, Bolstar, Penncap-M, Vydate or Vydate in combinations with Ambush, Bolstar or Mavrik was applied.

Phytotoxicity. Only Bolstar and Vydate treatments alone or in combination with other pesticides resulted in any noted phytotoxicity. The Bolstar treatments caused numerous chlorotic spots, about 0.1-0.2 in (3-5 mm) diameter, on the upper leaf surfaces. Bolstar in combination with Vydate produced many 0.04 in (1 mm) diameter necrotic spots on upper and lower surfaces of leaves. All other treatments containing Vydate caused slight necrotic areas on tips of leaves. No phytotoxicity was noted on any of the flowers.

Experiment 2—Fall 1980

Economically damaging population densities of spider mites, leafminers and spirea aphids developed on the experimental plants in the fall. Results of the pesticides' effects on these pests and parasitoids of the leafminer appear in Table 2.

Spirea aphid. Seven days after the 3rd experimental pesticide treatment was applied, spirea aphids were most numerous on flower peduncles of chrysanthemums on which no pesticides were applied or which were treated with Altosid or UC 55248 at the 1x rate. Few or no spirea aphids were found on peduncles of chrysanthemums treated with the other pesticides.

Twospotted spider mite. Four days after the 1st application of experimental pesticides the highest numbers of spider mites per leaf were found on untreated chrysanthemums and on chrysanthemums treated with Dursban at the 1x rate and Altosid. All other pesticides were included in the group from which the least numbers of mites were found at that time. Six days after the 4th application of experimental pesticides, mite densities were the greatest in the chrysanthemums to which no pesticides had been applied and to which Dursban at the 1x rate and Altosid had been applied. No mites were recovered from leaves to which Mavrik 2 EC was applied at the 2x rate. Low to intermediate densities of spider mites were found from plots treated with the other experimental treatments.

L. trifolii leafminer and leafminer parasitoids. Numbers of parasitoids of leafminers are dependent on the abundance of leafminer hosts; numbers of leafminer hosts are dependent on pesticidal treatments. Therefore, direct effects of pesticides on parasitoid mortality are not effectively measured by simply counting parasitoids that develop from leafminer populations that are also subjected to the pesticides. The % parasitism of leafminers by parasitoids is, however, a more effective parameter for evaluating the impact of pesticides on parasitoid survival. Percent parasitism is greatly affected by the presence or absence of a single parasitoid or leafminer when the total of these 2 groups is low. Thus, no % parasitism is presented in Table 2 when numbers of adult leafminers and parasitoids were less than 5. For this reason, no data are presented for % parasitism of leafminers from plots treated with Dursban at the 4x rate, Vydate when applied alone and applied in combination with Ambush and for Ambush alone.

Eight days after the 6th pesticide application, the highest numbers of mines were found when UC 55248 had been applied. The lowest density of mines occurred in plants treated with Mavrik 2 EC at the 2x and 4x rates, Penncap-M, Vydate, Vydate with Ambush or Ambush alone.

Just as UC 55248 resulted in the largest numbers of mines per chrysanthemum leaf, treatments of this compound resulted in the greatest numbers of adult leafminers developing from leaf samples held in the laboratory. Significantly more leafminer adults developed from leaves treated with UC 55248 at the 1x and 2x rates than developed from leaves to which no pesticides had been applied. The smallest numbers of adult leafminers developed from leaves taken from plots on which Dursban, Mavrik 2 EC or 20 WP, Vendex, Altosid at the 2.5x rate, Penncap-M, Vydate, Vydate with Ambush or Ambush alone were used. However, there was no significant difference between numbers of leafminer adults from plants treated with these pesticides and numbers of adults from plants treated with water alone.

Leafminer increase in response to pesticide use has been documented (1, 2) but the increase has usually been attributed to pesticidal induced reductions of regulating parasitoids. However, not only did UC 55248 result in the greatest numbers of leafminers, but it also was among the group that had the highest % parasitism of leafminers. Thus, it is unlikely that the observed effect of UC 55248 on leafminer can be attributed to the removal of leafminer parasitoids by the chemical.

The lowest rates of leafminer parasitism occurred in chrysanthemums treated with Dursban at the 1x and 2x rates, Mavrik 2 EC at the 2x rate and Penncap-M. The use of these treatments in chrysanthemums, when attempting to establish biological regulation of leafminers, could thus be unwise.

Phytotoxicity. One week after the 6th application of experimental pesticides, plants from only 2 treatments showed phytotoxicity symptoms. Vydate alone and Vydate in combination with Ambush resulted in small necrotic spots on the tips of leaves as was observed in the spring experiment. Charcoal residues from the Altosid treatments accumulated on leaves and in open flowers where this pesticide was used. Overhead watering in commercial operations might eliminate similar accumulations. No phytotoxic effects of any pesticides were found on flowers.

The apparent effects of an experimental treatment on mobile arthropods in small plots, as used in these experiments, sometimes may appear different from effects that would occur if the pesticide were applied throughout a pompon facility. When a pesticide with a short period of effectiveness is applied on small areas, target pests from outside the treated area may immigrate after the pesticide's effectiveness has diminished. Since the proportion of immigrating insects to insects present at the time of application in a large treated area would be much smaller than the proportion in a small treated area, the apparent effectiveness of pesticides applied on the larger area would be greater. Thus, some pesticides evaluated in these experiments may provide better control in commercial use than these data would indicate when considered without other information.

These data have demonstrated the responses to certain pesticides of populations of several arthropods important to chrysanthemum production. With these and other similar data, a chrysanthemum grower may insure the most effective use of pesticides and may be able to avoid pest increases caused by the disruption of natural control organisms.

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A RAPID AND SIMPLE METHOD FOR DETERMINING EVAPOTRANSPIRATION REQUIREMENTS FOR POTTED ORNAMENTAL CROPS[1]

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Abstract. **A method was developed for determining and estimating future water use for potted ornamental plants utilizing a capillary mat system, specifically measured plant parameters, a sensitive balance and a recording evaporimeter. Regression analysis was performed on data collected from the experiment's test plant, Rieger elation begonia (Begonia x heimalis Fotsch.), to develop predicting models. The final model included plant foliage height (cm), plant flower height (cm), and evaporative demand (mm) as independent variables to estimate water use. The coefficient of determination (r^2) value for the model was 0.92, alluding to large accountability for the variation by the parameters used in the model. The method used was evaluated as being very effective at generating reliable data in a short period of time.**

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