tissue the only protection mechanism is freeze avoidance. If INA bacteria are not present or if they can be removed it will be possible for plants to supercool to −7°C or −8°C and thus avoid freezing. It appears that ice nucleation active bacteria could be significant factors in frost susceptibility of plants.

Literature Cited

1. Anderson, J. A., D. W. Buchanan, R. E. Stall and C. B. Hall. 1982. Frost injury of tender plants increased by *Pseudomonas syringae* van Hall. J. Amer. Soc. Hort. Sci. (in press).
2. Arny, D. C., S. E. Lindow, and C. D. Upper. 1976. Frost sensitivity of *Zea mays* increased by application of *Pseudomonas syringae*. Nature 262:282-4.
3. Leben, C. and T. D. Miller. 1973. A pathogenic pseudomonad from healthy field-grown soybean plants. Phytopath. 63:1464-7.
4. Lindow, S. E., D. C. Arny and C. D. Upper. 1978. Distribution of ice nucleation-active bacteria on plants in nature. Appl. and Env. Micro. 36:831-8.
5. Marcellos, H. and W. V. Single. 1976. Supercooling and heterogeneous nucleation of freezing in tissues of tender plants. Cryobiology 16:74-77.
6. Vali, G. 1971. Quantitative evaluation of experimental results on the heterogeneous freezing nucleation of supercooled liquids. J. Atmos. Sci. 28:402-9.
7. Wood, G. R. and A. G. Walton. 1970. Homogeneous nucleation kinetics of ice from water. J. of Appl. Physics 41:3027-3036.

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POSTHARVEST CONTROL OF THE TWOSPOTTED SPIDER MITE ON CHRYSANTHEMUM AND CARNATION FLOWERS[1]

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Additional index words. *Tetranychus urticae* Koch, *Chrysanthemum* x *morifolium* Ramat., *Dianthus caryophyllus* L., *Phytoseiulus macrophilis* (Banks), predatory mite, dicofol, oxydemeton-methyl.

Abstract. **Flower dip preparations of dicofol (Kelthane) 35WP and oxydemeton-methyl (Metasystox-R) 25% EC and introductions of the predatory mite** (Phytoseiulus macropilis **(Banks)) were evaluated for postharvest control of the two-spotted spider mite** (Tetranychus urticae **Koch) on chrysanthemum** (Chrysanthemum **x** morifolium **Ramat.) and carnation** (Dianthus caryophyllus **L.) flowers. Numbers of spider mites in flowers were determined after ca. 1 and 2 weeks. Dicofol dips and 8 female** P. macropilis **per vase of flowers provided sufficient mite control to prevent damage to chrysanthemum flowers after 12 days. Dicofol, oxydemeton-methyl and 16** P. macropilis **released per vase of 10 carnation flowers reduced spider mite populations at 6 days. After 13 days the least number of spider mites were found on carnations to which 16** P. macropilis **had been released. No treatment eliminated spider mites on flowers. Adding a flower preservative to vase water did not affect mite control.**

Numerous arthropod pests such as caterpillars, leafminers, thrips and mites adversely affect the development of commercial chrysanthemum (*Chrysanthemum* x *morifolium* Ramat.) and carnation (*Dianthus caryophyllus* L.) crops. Only the latter 2 arthropod groups have the potential to cause serious postharvest crop losses in flowers.

An outbreak of thrips after chrysanthemum or carnation flowers have opened usually is controlled with 1 or 2 applications of available pesticides. Thus, thrips should rarely deteriorate flowers after harvest. The twospotted spider mite (*Tetranychus urticae* Koch) is, however, difficult to control during the latter developmental stages of the chrysanthemum or carnation crop. At that time, the plant mass reduces pesticidal coverage within the plant bed and some of the most effective miticides can be phytotoxic to flowers that are showing color. As a result, twospotted spider mites are sometimes present on flowers at the time of harvest.

Phytoseiulus macropilis (Banks) is a component of the predatory mite fauna of Florida (1). This mite feeds on the twospotted spider mite and is often associated with uncultivated and landscape plants that are infested with the twospotted spider mite. Hamlen (2) demonstrated that *P. macropilis* could be manipulated effectively as a biological control agent for *T. urticae* infestations of foliage plants in greenhouses.

This study was performed to evaluate the potential of 2 pesticidal and 1 biological control method to reduce twospotted spider mites on harvested carnation and chrysanthemum flowers. Pesticides selected for evaluation were chosen for their reputations for not causing phytotoxic reactions when applied 1 time to chrysanthemum flowers showing color. The study was also designed to evaluate the impact of a flower preservative with vase water on mite control.

Materials and Methods

Two experiments were performed on cut flowers in 1 quart (946 ml) clear glass vases filled with water. Vase water was changed and the lowest 2 inches (5 cm) of each stem was removed 3 times at 3 day intervals during both experiments. Vases were spaced 2 ft (61 cm) apart on laboratory tables. The laboratory was illuminated 9 hr each day and the temperature was maintained at ca. 78°F (26°C).

Chrysanthemums. Experimental units consisted of 3 stems of 'Manatee Yellow Iceberg' chrysanthemum with a total of 15 open flowers. The experimental design was a 2 x 4 factorial in 4 randomized complete blocks. Factor A was the condition of the water in the flower vases (the presence or absence of 0.32 oz (9 g) of Floralife® flower preservative). Factor B was flower dip preparations of water without miticide (check), dicofol 35 WP at 1.33 lb/100 gal (1.59 g/liter), oxydemeton-methyl 25% EC at 1.5 pint/100 gal (1.88 ml/liter) or 8 mated female *P. macropilis* of unknown age released per vase of flowers. Factor A treatments were applied at the same time that 5 twospotted spider mites were released on each flower. Few or no other mites were present on flowers at the initiation of the experiment. Factor B treatments were applied 6 hr later.

Carnations. Experimental units consisted of 10 stems of 'Elegance' carnations each with 1 open flower. Six randomly selected samples of 10 flowers from the population from which the experimental flowers were harvested hosted 57 (SE = 30) twospotted spider mites including their eggs

[1]Florida Experiment Stations Journal Series No. 3406.

when measured by the wash and filtration method described later in this section. Treatments in this experiment included dicofol 35 WP and oxydemeton-methyl 25% EC prepared as previously described. Other treatments were 4, 8 and 16 female *P. macropilis* predatory mites of unknown age released per vase of 10 flowers. All treatments were replicated 4 times and were applied at the time flowers were harvested and taken to the laboratory. Laboratory conditions and spacing of experimental units were the same as previously described. Floralife preservative solution was used in all vases.

Evaluations. Twospotted spider mite densities were evaluated in both experiments after ca. 1 and 2 weeks. In the chrysanthemum experiment, 5 flowers per vase were selected at random and examined on both dates. In the carnation experiment, 3 flowers on the first date and 6 on the second date were examined. Before each evaluation, chrysanthemum flowers were rated 1 to 5 for increasing petal injury due to spider mite feeding. Changes in carnation flower quality due to mite presence were also noted, but the injury was not rated.

Mite densities in flower samples were measured by placing shredded flowers into a 10 inch x 14 inch (25.4 cm x 35.6 cm) plastic bag with 1 pint (473 ml) of water and 0.07 oz (2 ml) of detergent. The bag and its contents were shaken for 30 seconds. The mixture was poured through a hardware cloth screen (to remove large flower parts) and collected in a 3.5 inch (9 cm) diameter No. 4 Whatman filter paper placed into a Buchner funnel over an Erlenmeyer vacuum flask. A low vacuum created by an electric vacuum pump moved the liquid through the filter paper and left the mites, their eggs, and small flower parts on the paper surface. The filter paper and impinged mites were placed into a freezer for 10 minutes to prevent the mites from migrating. All mites and their eggs on the filter paper were counted with the aid of a dissecting microscope.

Data were analyzed by an analysis of variance and significant differences among treatment means were determined by Duncan's New Multiple Range Test.

Results and Discussion

Chrysanthemums. There was no significant response of mite densities to the use of Floralife preservative in the vases or to the interaction of the solutions and the chemical and biological control treatments. Mite densities and flower damage were affected by Factor B treatments (Table 1). The number of spider mites plus their eggs in the check plots was 24.9 per flower after 7 days. At that time, there was a significant reduction in numbers of spider mite eggs but not in the motile mite forms in flowers treated with oxydemeton-methyl. Significantly fewer spider mites and eggs were extracted, however, from flowers treated with dicofol and flowers upon which *P. macropilis* were released. No *P. macropilis* were recovered from samples taken 7 days after initiation of the experiment. No noticeable flower deterioration had occurred from mites feeding at the 7 day sampling time.

Numbers of mites plus eggs per untreated flower had increased to 69.3 by the time of the second evaluation. Flowers treated with dicofol or flowers upon which *P. macropilis* were released still had significantly fewer spider mites than the check. In flowers to which *P. macropilis* had been released, 5.2 predatory mites and eggs were recovered per flower. A few predatory mites were found in flowers from other treatments probably due to migration among plots. Unacceptable spider mite damage (rating $\geq$ 3) occurred in untreated flowers and in flowers treated with oxydemeton-methyl. Flowers treated with dicofol or *P. macropilis* were not visibly damaged by spider mites during the 12 days of the experiment.

Carnation. Data of spider mite and predatory mite responses to miticidal and biological control measures on carnation appear in Table 2. Six days after establishing the experiment, the numbers of spider mites plus their eggs averaged 7.9 per untreated flower. At that time, there was no significant difference between numbers of mites or eggs in the untreated flowers and in the flowers which received 4 or 8 predatory mites per vase. There was a significant reduction in spider mites or eggs of the plots treated with dicofol, oxydemeton-methyl and *P. macropilis* applied at the rate of 16 per plot. No flower deterioration due to spider mite feeding was evident at the time of the first evaluation.

One week later, spider mites and their eggs had reached 91.8 and 99.9 (respectively) per untreated flower. Flowers treated with the 2 miticides or with predators at all 3 densities had significantly fewer spider mites than did flowers of the untreated check. Numbers of spider mites ranged from 23.6 to 32.0 per flower and numbers of spider mite eggs ranged from 15.7 to 31.9 per flower. The lowest density of spider mites and eggs occurred on flowers to which 16 predator mites were released per plot. Examination of all flowers 13 days after initiation of the experiment revealed that flowers to which 16 *P. macropilis* were released were the only ones with no visible mite damage.

These studies show that significant reductions in twospotted spider mite populations, 1 week after application can be achieved by postharvest treatment of flowers with chemical and biological agents. However, spider mite

Table 1. Numbers of twospotted spider mites (*Tetranychus urticae*) and predatory mites (*Phytoseiulus macropilis*) per chrysanthemum flower and index of flower damage.

Treatment	No. *T. urticae* after 7 days[z]		No. *T. urticae* after 12 days		No. *P. macropilis* after 12 days		Flower damage index after 12 days[y]
	Mites	Eggs	Mites	Eggs	Mites	Eggs	
Water	13.7 a[x]	11.2 a	32.1 a	37.2 a	0.1 b	0.0 b	3.5 a
Dicofol 35 WP (1.59 g/liter)	3.2 b	1.0 b	5.5 b	1.2 b	0.0 b	0.1 b	1.5 b
Oxydemeton-methyl 25% EC (1.88 ml/liter)	11.5 a	2.4 b	26.9 a	14.1 ab	0.1 b	0.2 b	4.3 a
P. macropilis[w]	2.3 b	1.4 b	3.6 b	1.4 b	4.0 a	1.2 a	1.0 b

[z]No *P. macropilis* found on this date. No visible mite damage.
[y]Flower damage index: 1 = no visible mite damage; 2 = few petals with small areas of collapsed tissue, damage not easily seen; 3 = many petals around the circumference of the flower with small areas of collapsed tissue, damage easily seen; 4 = most petals with a medium size area of collapsed tissue, damage easily seen; 5 = most petals with a medium to large area of collapsed tissue, damage easily seen.
[x]Values within a column followed by the same letter are not significantly (P $\geq$ .05) different by Duncan's New Multiple Range Test.
[w]Eight female *P. macropilis* mites were released per experimental unit of 15 flowers.

Table 2. Numbers of twospotted spider mites (*Tetranychus urticae*) and predatory mites (*Phytoseiulus macropilis*) per carnation flower.

Treatment	No. *T. urticae* 6 days after harvest[z]		No. mites and eggs 13 days after harvest			
			T. urticae		*P. macropilis*	
	Mites	Eggs	Mites	Eggs	Mites	Eggs
Water	3.5 a[y]	4.4 a	91.8 a	99.9 a	0.3 c	0.3 b
Dicofol 35 WP (1.59 g/liter)	1.4 b	1.0 b	23.7 b	19.8 bc	0.8 bc	1.4 b
Oxydemeton-methyl 25% EC (1.88 ml/liter)	1.3 b	0.2 b	23.6 b	31.9 b	0.1 c	0.0 b
P. macropilis (4)[x]	3.5 a	3.5 a	32.0 b	16.5 bc	3.6 a	8.5 a
P. macropilis (8)[x]	2.1 ab	3.5 a	26.4 b	15.7 bc	2.7 ab	7.3 a
P. macropilis (16)[x]	1.3 b	0.5 b	4.5 c	6.0 c	1.2 bc	3.0 ab

[z]No *P. macropilis* found on this date.
[y]Values within a column followed by the same letter are not significantly different ($P \geq .05$) by Duncan's New Multiple Range Test.
[x]The indicated numbers of *P. macropilis* were released per experimental unit of 10 flowers.

control beyond 1 week was not always successful with the chemicals tested and with *P. macropilis* released at the lower ratios to spider mites. Since mite densities at harvest and environmental conditions of the flower after harvest may vary from those existing in these experiments, further work would be required before any of the evaluated methods could become acceptable commercially. Preharvest mite management should be practiced to reduce the necessity for postharvest mite control.

Literature Cited

1. Muma, Martin H., and Harold A. Denmark. 1970. Arthropods of Florida and neighboring land areas. V. 6 Phytoseiidae of Florida. Fla. Dept. of Agric. and Consumer Services. 150 p.
2. Hamlen, R. A. 1978. Biological control of spider mites on greenhouse ornamentals using predaceous mites. Proc. Fla. State Hort. Soc. 91:247-249.

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AN ANALYSIS OF PESTICIDAL APPLICATION COSTS FOR CUT CHRYSANTHEMUM FLOWERS[1]

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Abstract. **A cost analysis was performed to determine the pesticidal application costs of spray (nozzle boom, span boom, air blast, portable hose, and central hose) and granular (single-row and multiple-row) systems on chrysanthemums** (Chrysanthemum **x.** morifolium **Ramat.). Investment, variable and fixed costs were calculated for each system to evaluate the total cost of pesticidal applications.**

The investment and fixed costs for the air blast sprayer were approximately twice the costs of the other spray systems. Variable costs, however, were largest for the portable and central hose systems due to the time required to apply pesticides. The total costs per acre revealed that the nozzle boom and span boom are the least costly to own and operate followed by the air blast sprayer. Other results describe the custom hire versus self application decision with owned machinery and equipment.

Florida nurserymen produced more than 270 acres of pompon chrysanthemums during 1980 with an average wholesale value of $27,533 per acre (5). Because of the high per acre value of this crop and potential of severe pest damage, flower producers have developed intensive pesticide application practices to insure the crops' marketability. Records of Price *et al.* (4) from 4 commercial pompon crops during the 1979-80 production year indicate that an average of 70 (range: 56-102) dosages of pesticides (including insecticides, miticides, fungicides and bactericides) were applied for control of pests during the 14-16 weeks of crop development.

Pesticides used in the pompon industry are formulated as liquids or powders to be mixed with water and applied as foliar sprays or formulated as granules to be applied directly to the soil. Most producers require the capacity to apply both spray and granular materials to control pests. Results of our recent interviews with 8 pompon growers in Florida indicate that foliar sprays are usually applied by 1 of 4 methods (nozzle boom, span boom, air blast and portable hose systems) and granules are usually applied by 1 of 2 methods (single-row applicator or multiple-row (3-7) applicator). The effectiveness of each application system is dependent upon many factors including the inherent properties of the system, the nature of the target pests, the nature of the pesticides used, the time spent in treating an area and the operator's skill.

Analysis

An understanding of the different components of total cost is essential for growers wishing to evaluate their current pesticidal application costs and the investment in new pesticide application machinery and equipment. This

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