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 ≧ .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.

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

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Additional index words. investment costs, variable costs, fixed costs, custom hire, replacement decision, spray system, granular system.

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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economic study presents the costs of pesticide application for the 6 indicated methods and a centralized hose system in use by Colombian pompon producers, but not presently used by pompon producers in Florida. The pesticidal application costs developed will provide the basic cost information necessary to establish future economic injury threshold levels for pests associated with pompon chrysanthemum production. In this analysis, the evaluation of a pesticidal application system depends solely on the investment, variable and fixed costs of the system.

Description of Pesticidal Application Systems

1. Nozzle boom sprayer—30 horsepower, diesel, high clearance tricycle tractor, center mounted 200 gallon spray tank with a drop boom and spray nozzles.
2. Span boom sprayer—30 horsepower, diesel, high clearance tricycle tractor, center mounted 200 gallon spray tank with a drop boom and dispersal fans.
3. Air blast sprayer—trailer mounted 500 gallon spray tank, PTO driven pump, hydraulically rotating spray head, spray distance 75 ft. and pulled by a 80 hp diesel tractor.
4. Central hose sprayer—stationary 1000 gallon spray tank with a 30 horsepower diesel pump used to deliver spray materials through a 1.25 inch diameter galvanized pipe to the central portion of the house where hoses are utilized to manually apply the spray.
5. Portable hose sprayer—trailer mounted 500 gallon spray tank, hose, nozzle, hose rack reel, 12 horsepower pump and pulled with a 40 horsepower diesel tractor.
6. Multiple-row granular applicator—spiral flo applicator mounted on 30 horsepower, diesel, high clearance tricycle tractor.
7. Single-row granular applicator—Custom built gravity flo applicator, mounted on a bicycle frame and propelled by a 5 horsepower gasoline engine.

The above described pesticidal applications systems were evaluated for a 20 acre saranhouse site. It was assumed that 1.5 chrysanthemum crops could be grown annually per acre in the proposed structure (20 acre site x 1.5 crops per year = 30 acres per year).

Variable and Fixed Costs

Costs were separated into two categories, variable and fixed costs. Variable costs describe those costs that vary with output during the production process. The variable costs are related to the price and quantity of such factors as fuel, oil, lubricants and labor. Fixed costs, however, are unrelated to output and do not vary during the production process. The fixed costs considered include such costs as depreciation, insurance, repairs, taxes (real and personal property) and interest (3).

The variable costs of fuel, oil, and lubricant in this study were estimated from published engineering data (2). Labor cost was calculated for the various systems from application time requirement information furnished by flower producers and industry representatives.

The fixed costs (depreciation, insurance, repairs, taxes and interest) were estimated for each item of machinery and equipment. Depreciation, a non-cash cost, is a procedure for allocating the usefulness of an asset over its life. Straight-line depreciation, investment cost minus salvage value divided by useful life, was used to calculate annual depreciation. All machinery and equipment were assumed to have a useful life of 10 years except the granular applicators which had a useful life of 5 years. Annual insurance costs were estimated at 0.5% of the average of investment cost and remaining depreciable value. Annual repair costs were estimated at 10 percent of investment costs. Taxes were calculated at 70 percent of investment cost times the millage rate of $17/1000. Interest cost was calculated at 14 percent of the average of investment cost and salvage value.

Variable and fixed costs were summed to determine the total cost of applying pesticidal materials per acre. These costs (variable, fixed and total) were used to evaluate the conditions of custom hire application versus self application using owned machinery and equipment and to evaluate whether to replace an existing system with a new system.

Custom Hire Vs. Self Own and Operate

The decision of custom hire application versus self application using owned machinery and equipment involves both qualitative and quantitative factors (1). The qualitative factors, such as performing the management practice using a particular method or at a preferred time, are often very difficult to measure or value and will not be evaluated in this study. The quantitative factors, though, are easier to measure and can be used for comparison to make an economically sound choice. The factors necessary to evaluate this decision include the costs of owning and operating the machinery and equipment for self application and the local contract rate for custom hiring the application of pesticidal materials. After compiling the aforementioned data, the following equations may be utilized to resolve the custom hire versus self application with owned machinery and equipment.

$$A = \frac{FC}{CH - VC} \qquad \text{(Equation 1)}$$

where
- FC = total annual fixed cost of owning the machinery and equipment ($).
- CH = custom hire rate per acre for the entire season ($/AC).
- VC = variable cost of operating machinery and equipment per acre for the entire season ($/AC).
- A = minimum number of acres per year that must be treated in order to profitably own and operate machinery and equipment (AC).

and

$$CH = FC + VC \qquad \text{(Equation 2)}$$

where
- FC = total annual fixed cost per acre of owning the machinery and equipment ($/AC).
- VC = variable cost of operating machinery and equipment per acre for the entire season ($/AC).
- CH = custom hire rate per acre for the entire season ($/AC).

The solution to equation 1 reveals the minimum number of acres per year that must be treated in order to profitably own and operate the machinery and equipment for pesticidal applications. Therefore, based on the annual expected potential use (acres) of the machinery and equipment, the producer can readily make an informed decision. Furthermore, equation 2 may be used to determine the maximum contract rate that a producer can afford to pay before purchasing his own machinery and equipment or operating currently owned machinery and equipment.

Selection and Replacement Decision

The selection and/or replacement decisions are also based on costs. These decisions, unless adjustment is necessary for differences in capacity, effectiveness, etc., require one to know the variable and fixed costs of the systems under comparison. The selection decision among new systems is based on the lowest total cost (variable plus fixed costs). The replacement decision, however, is based on the variable cost of the existing system, assuming that the fixed costs have already been exhausted, and the variable and fixed costs of the new system. Therefore, in order for a new system to be economically feasible, the variable costs of the existing system must be greater than or equal to the variable and fixed cost of the new system.

Results and Discussion

The investment costs of the pesticidal application systems varied greatly, as shown in Table 1. Among the spray systems, the air blast sprayers had the highest investment cost (due in part to the necessity of a larger horsepower tractor to pull and operate the sprayer), while the central hose spray system which required the use of galvanized pipe to transport the pesticide to the desired location had the lowest investment cost. The investment cost of the nozzle boom, span boom and portable hose spray systems were similar. In addition, the investment costs of the granular applicators were comparable, except that the multiple-row granular applicator required the use of a high-clearance tractor for operation.

Table 1. Estimated machinery and equipment investment cost for pesticidal applications on cut chrysanthemums, 1981.[z]

Item	Investment costs ($)
Spray System	
Nozzle boom	
(high-clearance tractor)	18,720
Span boom	
(high-clearance tractor)	18,920
Air blast	
sprayer	19,000
tractor (80 hp)	20,000
	39,000
Central hose	
(galvanized pipe system)	18,030
Portable hose	
sprayer	7,573
tractor (40 hp)	11,000
	18,573
Granular System	
Multiple-row applicator	
spiral-flo	1,000
high-clearance tractor	18,720
	19,720
Single-row applicator	
(custom designed,	
self-propelled)	1,000

[z]Investment cost is the amount of capital necessary to purchase the machinery or equipment item.

The fixed costs of the pesticidal application systems for cut chrysanthemum production varied according to their investment costs, as shown in Table 2. The major portion of the fixed costs were composed of depreciation, repairs and interest on investment. Fixed cost per acre and fixed cost per application were calculated assuming a production level of 30 acres annually and 31 trips over an acre for the spray systems and 4 trips for the granular applicators. The fixed cost per application for the spray systems ranged from $5.15 for the portable hose sprayer to $10.97 for the air blast sprayer, while the granular systems ranged from $.35 to $.93 per application for the single-row and multiple-row applicators, respectively.

Table 2. Estimated annual fixed cost of machinery and equipment for pesticidal applications on cut chrysanthemums, 1981.

System	Annual fixed cost[z]	Fixed cost/ac[y]	Fixed cost/ appl[x]
Spray System			
Nozzle boom			
(high-clearance tractor)	5,310	177	5.71
Span boom			
(high-clearance tractor)	5,366	179	5.77
Air blast			
sprayer	5,390	180	5.81
tractor (80 hp)[w]	4,823	160	5.16
	10,213	340	10.97
Central hose			
(galvanized pipe system)	5,115	171	5.52
Portable hose			
sprayer	2,148	72	2.32
tractor (40 hp)[w]	2,653	88	2.84
	4,801	160	5.16
Granular System			
Multiple-row applicator			
spiral-flo	337	11	.35
high-clearance tractor[v]	530	18	.58
	867	29	.93
Single-row applicator			
(custom designed, self-propelled)	337	11	.35

[z]Annual fixed cost include annual depreciation, insurance, repairs, taxes and interest.
[y]Fixed cost/AC was calculated by dividing the annual fixed cost by the number of acres produced annually. It was assumed that 20 acres would be the size of the operation and that an individual would produce 1.5 crops per year on each acre (i.e. 20 acres x 1.5 crops/year = 30 acres/year).
[x]Fixed cost per application was calculated by dividing the fixed cost per acre by the number of applications per crop. In this study it was assumed that all assets were used to apply pesticidal materials for 31 applications (31 trips over an acre) per crop, except for 4 applications of granular material.
[w]Tractors were assumed to be used 85 percent of the time for pesticidal applications.
[v]The high-clearance tractor was assumed to be used 10 percent of the time when applying granular material through the spiral-flo distributor.

The variable costs per acre for pesticidal applications (less chemical costs) are described in Table 3. Variable costs per hour were calculated for each system according to the required use of fuel, oil, lubricants and labor. Time required for an application (hours/acre) multiplied by the variable costs per hour (dollar/hour) yields the variable cost per acre (dollars/acre). The total variable cost per application was sensitive to the magnitude of the variable cost per hour and time per application.

The resulting variable cost per application revealed that the portable hose and central hose sprayers had the highest variable costs for the spray systems, $23.15 and $17.63, respectively. The variable cost per application of the nozzle boom, span boom and air blast sprayers were substantially lower due to their low variable cost per hour and time required for application. Granular systems ranged from $4.51 to $6.07 for the single-row and multiple-row applicators.

The total variable and fixed costs per acre are summed to determine the total cost of the pesticidal applications (without pesticide costs) for each system (Table 4). The total costs per acre for the spray systems indicate that the nozzle and span sprayers are the least expensive to own and operate followed by the air blast sprayer. The central hose and portable hose sprayers resulted in the highest total costs per acre. The total cost per acre of granular systems are $53 and $29 for the multiple-row and single-row granular applicators, respectively.

The information necessary to determine whether to custom hire or self perform pesticidal applications with

Table 3. Estimated variable costs per acre for pesticidal applications on cut chrysanthemums, 1981.[z]

System	Variable costs/hour	Time/application	Variable costs/application	Variable[y] costs/ac
	($/hr)	(hr/appl)	($/appl)	($/AC)
Spray System				
Nozzle boom (high-clearance tractor)	6.07	0.75	4.55	141.00
Span boom (high-clearance tractor)	6.07	0.75	4.55	141.00
Air blast tractor (80 hp)	9.52	0.75	7.14	221.00
Central hose (galvanized pipe system)	7.05	2.50	17.63	547.00
Portable hose tractor (40 hp)	9.26	2.50	23.15	718.00
Granular System				
Multiple-row applicator, spiral-flo (high-clearance tractor)	6.07	1.00	6.07	24.00
Single-row applicator (custom designed, self-propelled)	4.51	1.00	4.51	18.00

[z]Variable costs include only the costs of fuel, oil, lubricants and labor.
[y]Assumes 31 and 4 applications for spray and granular systems, respectively.

Table 4. Estimated total variable and fixed cost per acre of pesticidal applications on cut chrysanthemums, 1981.[z]

System	Fixed costs/ac	Variable costs/ac[y]	Total costs/ac
Spray System			
Nozzle boom	177	141	318
Span boom	179	141	320
Air blast	340	221	561
Central hose	171	547	718
Portable hose	160	718	878
Granular System			
Multiple-row applicator	29	24	53
Single-row applicator	11	18	29

[z]Does not include the cost of chemicals used, only the cost of their application.
[y]Assumes 31 applications for all systems except the multiple-row and single-row granular applicators where 4 applications were required.

owned machinery and equipment is reported in Table 5. The analysis was further extrapolated to include situations where a producer only incurred 50 and 25 percent of the 1981 fixed costs (assumes the producers' fixed costs on machinery and equipment would be less if purchased prior to 1981) associated with each of the pesticidal application systems. This evaluation allows an individual the opportunity to compare his total costs per acre with potential custom hire costs per acre. The custom hire rates vary greatly among the systems, but are similar between levels of the fixed costs. The systems with the higher variable costs, such as the portable hose sprayer, affect the custom hire rate the least. Therefore, given the costs to own and operate pesticidal application machinery and equipment and the annual use (acres), the producer can make an informed decision about which custom hire rate would be desirable for his operation.

The replacement decision of an existing system, however, requires a different evaluation. In order to change from an existing pesticidal application system, the fixed and variable costs of the new system must be less than the variable costs of the existing system. For example, a grower will not save money by abandoning an air blast sprayer with annual variable costs of $221/acre and replacing it with a nozzle boom sprayer that has an annual fixed and variable costs of $318/acre.

Table 5. Estimated annual maximum custom hire rate per acre that a producer would pay before owning and operating pesticidal application machinery and equipment, based on 1981 variable and fixed costs.[z]

System	Maximum[y] custom hire rate 100% of 1981 fixed costs	Maximum[x] custom hire rate 50% of 1981 fixed costs	Maximum[w] custom hire rate 25% of 1981 fixed costs
	($/ac)	($/ac)	($/AC)
Spray System			
Nozzle boom	318	230	185
Span boom	320	231	186
Air blast	561	391	306
Central hose	718	632	
Portable hose	878	828	758
Granular System			
Multiple-row applicator	53	38	31
Single-row applicator	29	24	21

[z]The estimated annual maximum custom hire rate per acre evaluation includes situations where the producer incurs 100, 50, or 25 percent of the 1981 fixed costs (assumes the producers fixed costs on machinery and equipment would be less if purchased prior to 1981). Pesticide costs are not included in this evaluation.
[y]The maximum custom hire rate is the highest contract rate that a producer would commit himself to before self performing the pesticidal applications with his own machinery and equipment purchased and operated at 1981 variable and fixed costs. Assumes 31 spray and 4 granular applications per acre for the spray and granular systems on 30 acres, respectively.
[x]Evaluates custom hire decision if the producers fixed costs are 50 percent (one half) of the fixed costs reported for 1981 costs.
[w]Evaluates custom hire decision if the producers fixed costs are 25 percent (one-fourth) of the fixed costs reported for 1981 costs.

Growers will adopt pesticidal application systems that produce favorable results and minimize application costs. The use of these and other pesticidal application systems will undoubtedly continue to play an important role in Florida's ornamental industry. Producers who understand that pest control is a necessary production input which requires management and large capital expenditures will likely benefit from the planning of economically efficient pesticidal application systems.

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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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