SOME ASPECTS OF PEST MANAGEMENT IN INTERIOR LANDSCAPES

by

Keith Jongejan

B.Sc. (Hons.), Carleton University, 1980

PROFESSIONAL PAPER SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF PEST MANAGEMENT

in the Department

of

BIOLOGICAL SCIENCES

SIMON FRASER UNIVERSITY

February 1986

Approval

Name: Keith Jongejan

Degree: Master of Pest Management

Title of Thesis: Some Aspects of Pest Management in Interior Landscapes

Examining Committee:

Chairman: Dr. P. Belton

Dr. M. Mackauer, Senior Supervisor

Prof. T. Finlayson, Professor Emerita

Dr. N. Angerilli, Research Scientist

Dr. H.R. MacCarthy, Adjunct Professor,
Biological Sciences, Non-member of
Supervisory Committee

Date Approved: 4 February 1986

Title of Thesis/Project/Extended Essay

Some aspects of Pest Management in Interior Landscapes

Author:

(signature)

Keith Jongejan

(name)

10 MARCH 1986

(date)

ABSTRACT

The Interior Landscape Industry is a relatively recent development. Pest management within this industry is presented with some challenging problems to overcome. A major problem is due to interior landscapes being mainly in public areas, as opposed to agricultural crops, for example, which are essentially private areas. The use of pesticides in interior landscapes, and the choice of which pesticide to use is, therefore, restricted. Biological controls, which are used successfully in greenhouses, another interior location, would appear to be an ideal alternative. However, availability, compatibility, and environmental problems restrict the use of this strategy as well.

This paper describes the breadth of arthropod pest problems in interior plantscapes, determines which pest problems are present in the interior landscape industry of Vancouver, British Columbia, and shows how they are approached. Research was conducted using questionnaires, of which two types were developed, one for managers and one for employees of the interior landscape firms.

While a number of pests are found in interior landscapes (about 40 species have been listed in the scientific literature), mites have been cited by the questionnaire respondents as the most frequent and most difficult to control. Scales and aphids are the next most difficult to control.

Safer's® Insecticidal Soap is the most widely used pesticide, while diazinon ranks second. However, after Safer's®, employees tended to prefer the use of non-chemical strategies more frequently than any other method. At the time of the questionnaire, biological control agents had been tried by 25%, and were used by 16% of the respondents.

ACKNOWLEDGEMENTS

First and foremost, thanks must go out to the employees and managers of interior landscape firms who took time to answer the questionnaires. Without their co-operation a greater part of this paper would not have been possible.

Thanks also to the people who helped me develop the questionnaires in the first place: Gwen Jongejan, Mathilde Bissang, Bob MacDonald, Dr. C. Brogan, and of course, my supervisory committee.

A special thank-you to Ila Cornish, Pesticides Directorate, who provided me with computer output to sort through, and answered my many questions. Thanks also to Tom Davis, Pesticides Directorate, and to René Roddick, B.C. Hydro, who provided the hard-to-find microfiche set of pesticide labels.

For providing assistance in proofreading the various drafts of the paper, thank you Keith Cunningham.

Last but certainly not least, thanks go out to my supervisory committee, Dr. M. Mackauer, Prof. T. Finlayson, and Dr. N. Angerilli, for providing suggestions, editorial assistance and all the other things a supervisory committee is supposed to do.

TABLE OF CONTENTS

LIST OF TABLES

A. INTRODUCTION

Plants have been used indoors as decoration for centuries. However, the production of indoor plants on a mass scale is a recent development. Along with this increase in production, a service industry has developed, which is currently described as 'Interior Landscaping', 'Interior Plantscaping', or 'Interiorscaping'. The following paper concentrates on the arthropod pest problems encountered in this industry.

The Interior Landscape Industry as defined in this paper will be those firms which offer plant maintenance services to various commercial establishments, such as, offices, hotels, and shopping malls. These firms provided up-to-date information for this paper through completion of questionnaires. In addition, a literature search provided information about the breadth of pest problems possible.

Information on events prior to plant placement would give a better overall picture, but due to space limitations it will receive only minor attention in this paper. The events that are a consequence of placement in an interior setting, in particular the arthropod pest problems, are the main focus of this paper. Effective pest managers need to know the whole picture in order to best determine the cause of and solution to pest problems.

I. The importance of indoor plants.

Man has been growing plants in containers since the time of the Sumerians and ancient Egyptians, some 3,500 years ago (Smith & Scarborough 1981). This interest in plants has continued to the present. A quote from Manaker (1981, p.1) sums up recent developments:

> "Interior planting is not a fad. It is part of the back-to-earth, back-to-nature, back-to-the-senses movements evolving in our culture today. Indoor plants may no longer be nonessential luxuries, but necessities - just as our automobiles and television sets are "necessary," playing a very important role in the American way of life."

It is believed that humans have a primal need for plants. In the absence of greenery people become unhappy or depressed (Conklin 1972). "Plants exert direct, specific, and positive effects as stimulus objects" (Manaker 1981, p.2). Plants also provide the senses with relief from a harsh urban environment (McDuffie 1984).

As well as adding to the aesthetics of the surroundings, plants are used indoors to direct traffic, provide screens, soften harsh architectural surfaces, and add texture to nondescript surfaces. Interior landscapes can reduce large areas to human scale. Plants can also reduce the lack of privacy, add natural colour, and alter the acoustics of an area. In addition, they aid in air purification through photosynthesis (Topping 1980, McDuffie 1984).

The commercial use of plants indoors originated in the early 1960's when a new concept in office design was developed in West Germany (Conklin 1972). This 'office landscaping' was an open system where the floor of the office building is made up of office furniture, screens, and many living plants. Research into employee attitudes regarding the old and new design systems revealed that a great majority of the employees in the planted offices felt more content but could not explain why. "Is this not primal association?", Conklin (1972) asked. Similar office design concepts were later adopted in North America and studies here revealed that morale was increased and absenteeism reduced.

Certainly, for some, the most attractive aspect of interior plants is the ability to reflect a company's desired image. Healthy, clean plants reflect a healthy, clean company. As well, the arrangement of the plants in the worker's area can be altered from time to time. This occasional change can stimulate appreciation in the worker, and in turn, may improve the productivity and increase profits for the company (Topping 1980). Thus a well-designed interior planting could repay the investment several times over. With about 500 species and cultivars of foliage plants grown for indoor use, designing an interior landscape well is not an easy project. The correct types of plants must be chosen and properly arranged to create the desired effect for the area (Woodham & Gainey 1980*a,b*).

II. Origin and production of interior foliage plants.

The tropical and subtropical regions of the world are the natural origin of most plants used in interior landscapes. Many of these plants were discovered on plant exploration expeditions (Pemberton 1980). Prior to 1929, these expeditions were mainly in search of new fruits and vegetables; ornamental plants were a sideline. It was only after 1929 that some expeditions searched exclusively for ornamental plants (Manaker 1981). Breeding and naturally-occurring mutations have also provided plants for interior use.

Approximately 75% of North American foliage plants are propagated on a large scale in the southern USA, particularly in the states of Florida, Texas, and California. The remaining 25% is produced in Latin American and Caribbean countries. Florida is currently the leading state with about 55% of domestic production (table 1), while California produces 20% and Texas 5%. Plants produced in these latter states are generally for local use, while 90% of the Florida plants are sold throughout North America.

In addition to open fields, foliage plants are grown under a variety of structures, such as, glass, plastic film, or fibreglass greenhouses, and shade structures of slats or shade cloth (Conover *et al*. 1973). Local climate influences the type of growing structure employed and also the choice of plants grown.

Shade structures are commonly large enough to accommodate the necessary machinery (Conover 1969). These structures aid in acclimatizing the plants, by preparing them for the lower light levels found indoors. Shade cloth is used for the same purpose in greenhouses. Production of plants under full sun still occurs, but the use of this method is declining (Conover 1974).

As previously mentioned, 90% of the foliage plants produced in Florida are used elsewhere in North America. The most economical means of shipping plant material out of Florida is usually by truck. Deliveries can be made to most points in North America in under 5 days (Poole & Conover 1982). The conditions in which the plants arrive at the destination, however, are dependent in part on the production methods.

Table 1. Wholesale values of foliage plants produced in selected states (1981).

State	value[1] ($1000)
Florida	162,158
California	77,352
Texas	29,425
Ohio	13,988

[1]U.S. Crop Reporting Board 1982

For example, *Ficus benjamina* L. (weeping fig) grown under 63% shade suffered less leaf drop than did similar plants produced under 30% shade and full sun (Poole & Conover 1982).

III. Characteristics of the interior environment.

Before placing plants indoors a complete evaluation of the interior environment ought to be conducted. Measurements and estimates of year-round light intensity, quality, and duration, high and low temperatures, relative humidity, water quality, expected pedestrian traffic patterns, and the location of heating, cooling, or ventilating systems should be made (Manaker 1981). The following will briefly describe some of these aspects.

1. Light

Light is the most important factor influencing interior plant maintenance (Conover & McConnell 1981). Photosynthesis and the synthesis of chlorophyll requires wavelengths of light in the red and blue regions to be present. The human eye, however, is most sensitive to wavelengths in the yellow-green region; and consequently interior lamps are manufactured to produce peaks in this region. The emissions in the red and blue regions vary according to the type of lamp. Cool-white fluorescent lamps have been shown to produce higher peaks in the photosynthetically active region than other types of lamps, such as a Gro-lux®, or mercury or metal halide lamps (Gaines 1977).

Cathey *et al.* (1978) compared the growth of different plants under 7 types of fluorescent lamps and all grew acceptable plants. However, cool-white and warm-white lamps were more efficient in converting power to visible radiation and also maintained their output over a longer period of time than did other growth lamps.

The amount of light available should be above the plant's light compensation point. "This is the intensity at which carbohydrate production is just sufficient to equal that utilized by respiration, with none left over for other plant functions. Plants cannot survive at light levels as low as the compensation point or less" (Conover & Poole 1981, p.270). However, if a plant is installed into an area where the light is below its light compensation point, then it usually has enough food reserves (which were produced by the plant while under higher light levels) for it to survive for some time. However, the plant is still in a stressed situation because it cannot replenish those food reserves. Pest populations usually develop faster than the time it takes to use the food reserves, thus in all probability, it will be the pest problems that will cause the decline of the plant before it depletes its food supply.

2. Temperature

Temperature is another important factor for plant health and one that is usually disregarded (Conover & McConnell 1981). Comfortable temperatures for humans are not always ideal for plant health. Plants used indoors do well in day temperatures between 21°C and 27°C and night temperatures between 18°C and 21°C. Temperatures below 18°C will stop most plant growth. In large buildings the temperature is generally reduced to 13°C or below on weekends. Plants situated in draughty areas near windows, cooling vents, and entrances (especially in geographic areas that have freezing winters) usually do not survive long. Chilled leaves may blacken and appear water-soaked.

3. Humidity

Lack of humidity is another problem found indoors, especially during the winter months when the heating system is on. Plants can tolerate humidities as low as 50%. Indoor humidities of 10% have been recorded when investigating cases of plant damage. Marginal necrosis is the common injury resulting, which detracts from the overall appearance. "Healthy plants with strong root systems are better able to withstand low humidities than plants with poor root systems or poor food reserves" (Conover & McConnell 1981). In general, though, humidities at which humans are comfortable are sufficient for plant health.

B. THE QUESTIONNAIRE

The range of pest problems encountered in the interior landscape industry was determined by a literature search. To complement this information a questionnaire was developed and distributed to firms in the Vancouver, British Columbia, area that offer interior plant maintenance services. The questionnaire was designed to obtain information about which pests were causing the most problems, how they were controlled, and where they fit into the overall scheme of problems encountered in the interior landscape industry. The questionnaire also gathered background information about the respondent and the firm itself. These initial few questions were intended to be easy to answer, in order to relax the respondent and get him to be more willing to answer the remaining questions (Oppenheim 1966).

One type of questionnaire was developed for managers (Appendix B) and one for employees (Appendix C). The managers' questionnaire was basically the same as the employees' with a few extra questions relating to the overall management of the firm.

The contents of the questions were based on my experience when employed as a plant maintenance employee. In order to decrease the number of ways a question could be interpreted, feedback was sought from a wide variety of people, some of whom had been associated with the industry, while others were not.

The 1984 Yellow Pages™ for Vancouver, British Columbia, served as the source for potential participants in the survey. All firms under the 'Plant Shop' section were contacted by telephone. To those that offered plant maintenance services, the reason for the survey was explained. They were then asked if they were willing to participate in the survey. Only one refused, saying he was going out of business. A few could not be contacted, even after leaving several messages on their answering machines.

The number of manager and employee questionnaires sent out to each firm was based on the initial telephone conversations. Each questionnaire had a covering letter (Appendix A) explaining what the survey was about. A return envelope, stamped and addressed, was included to ease the 'burden' on the respondent, and provide anonymity. This was a possible concern, since some employees, fearing the loss of their employment, might be unwilling to submit their questionnaire to their employer (Dr. C. Brogan, pers. comm.)[1]. Anonymous mail questionaires are also more likely to provide "frank and revealing responses" (Oppenheim 1966). Since the number of possible respondents was low, every attempt was made to encourage responses.

Out of 37 firms listed in the Yellow Pages™, 17 were involved in plant maintenance and were willing to participate. In total, 50 employee and 24 manager questionnaires were sent out. Out of these, 9 employee and 14 manager questionnaires were returned (30% of the total sent out, or 18% of the employees and 58% of the managers). There is quite a difference in the percentage of returns between the employees and managers. This could be due to a number of reasons. If one assumes that the rate of return indicates interest; then the managers have shown a greater interest in the questionnaire because:

a. they are managers, and have shown enough interest in the area to attain the position they now hold; or
b. they are interested because the results may supply them with information on how to run their business more effectively; or
c. managers thought their company name might be printed somewhere and therefore it would be good for business to reply; or
d. managers are more highly educated and are more interested in research.

Conversely, the employees have shown less interest because:

a. this is just another job for them; or
b. 'paper work' is for managers.

And on the otherhand, the rate of return may not be indicative of interest, but be due to:

a. employees not having enough time to fill out the questionnaire; or
b. employees did not feel the questionnaire was anonymous.

---

[1] Educational Research Institute of BC.

C. THE INTERIOR LANDSCAPE INDUSTRY OF VANCOUVER, B.C.

The size of the firms offering indoor plant maintenance services in the Vancouver, B.C., area varies greatly (M:3)[2]. Many are new, small, and often one-person operations, a few are large and well established (table 2). Since more than one manager questionnaire was sent to some firms an accurate total of the number of employees cannot be reported. However, after deleting presumed duplicate answers, the number is estimated to be around 90 full-time and about 20 part-time employees. Of the employee respondents (E:4), 6 worked full time, 3 part time. The median length of time employed for an employee (E:1) was 5 years, while for a manager (M:1) it was 7.5 years. According to the managers, most employees work alone (78%) while 15% work in pairs (M:4). Of the nine employees that responded 8 worked alone, while 1 worked alone at some times and as part of a pair at other times (E:5).

One method of operation in the interior plant maintenance industry is to divide the city into areas and assign each area to an employee. The frequency of visits to the clients is usually once a week, thus each area can be subdivided into five easily travelled routes which will encompass all clients in the area. Any new client a firm receives is usually given to the person responsible for that area. When considering plant health, ideally a person should remain responsible for an area as long as possible. However, this becomes tedious for the employee and, therefore, routes are rotated. But it takes time to get accustomed to specific plants. Granted, each species or cultivar in general requires the same amount of water, however the amount will vary according to location since each plant will dry out at different rates. People unfamiliar with a route will have to learn this by trial and error. Even with excellent personnel, however, it is almost impossible not to replace some plant material during this trial and error period (Mastick 1977).

---

[2] Many of the questions are duplicated in both questionnaires. The questions will, therefore, be identified by the number of the question preceded by either an 'M' or an 'E', depending on which questionnaire it is found in. For example M:21/E:9 is the same question, but number 21 in the manager questionnaire and number 9 in the employee questionnaire.

Table 2. Company statistics.

	median	range
length of time firm in operation (years)	10.0	1.1-64
number of people employed		
full time	3.5	0.0-53
part time	1.5	0.0-12
length of employment (years)		
managers	7.5	1.1-33
employees	5.0	2.7-10

In Vancouver, 8 of the manager respondents said they had different routes (M:5). Of these eight, 6 rotated people from route to route. Comments were added that it was "necessary after 1-2 years", or that it was done "every few months to 2 years, thru [*sic*] attrition, promotion, floaters who always rotate". Seven employee respondents visit each client once per week, the two remaining visit once or twice a week depending on the client (E:6). Of the maintenance managers[3] 6 visit once a week, 2 twice a week, and 2 once or twice a week depending on the client (M:19-20). (One non-maintenance manager also visits once a week, an explanation was not given).

In the overall operation of the Vancouver firms (M:11), 'labour' was the expense category which ranked the highest. 'Plant replacement' was ranked second,

---

[3] Up to this point reference has been made only to two groups; employees and managers. Managers, however, can be further subdivided depending on their response to question M:19; whether or not they are involved in hands-on plant maintenance. There were 10 'maintenance managers' and 4 'non-maintenance managers'.

'transportation' costs third and , 'chemicals' fourth. In the 'other' category 'overhead' was mentioned by four manager respondents. In the overall perspective 'overhead' ranks fifth, while among only those who responded with 'overhead' it ranked second, with 'labour' first, 'transportation' third, 'plant replacement' fourth, and 'chemicals' fifth.

Question M:8 asked if any of the respondents had any problems in obtaining quality plant material. Eleven respondents answered no, while one respondent did and the other two did occasionally.

Ranking the causes of plant loss was determined using data from question M:12/E:8. Respondents were asked to give 5 causes of plant loss in decreasing order of importance. Their responses were then ranked; a '5' for their most important cause, a '4' for the next most important, and so on. These ranks were then summed for each type of response and the results are shown in table 3.

'Poor light' was considered by all groups to be the primary cause of plant loss in interior environments. 'Insects' and 'disease' were ranked second and third by both types of managers. Employees considered 'watering techniques' to be more important than 'insects' or 'disease'.

A few of the other causes listed in table 3 might require some comment. 'Salt burn', considered only by employees, is a result of overfertilization. 'Lack of care', considered by both types of managers, is probably an opinion of their employees' work habits. 'Client overwatering' can be due to a number of reasons: 1) the client doesn't agree with the methods used by the employee, and therefore corrects them; or 2) the client mistakenly thinks the employee has not visited, and therefore waters the plants as well. 'Mechanical damage' is usually due to the plant being placed too close to high traffic areas. 'Movement by client' refers to the tendency of some clients to move plants away from the original position. When the plants are first installed, they are (usually) placed in a spot where the plant is expected to do well. The new location determined by the client is not always as good and may affect plant health and appearance.

Table 3. Causes of plant loss in interior landscapes (Question M:12/E:8).

RANK[1]	EMPLOYEE	RANK[1]	MAINTENANCE MANAGER	RANK[1]	NON MAINTENANCE MANAGER
43	poor light	39	poor light	22	poor light
36	watering technique	23	insects	14	insects
23	insects	13	disease	13	disease
17	disease	14	temperature	11	watering technique
10	temperature	7	watering technique	4	mechanical damage
4	salt burn	5	mechanical damage	4	lack of care
3	viruses	5	old age	3	temperature
1	mechanical damage	4	poor potting soil		
1	not transplanted	3	lack of care		
		3	poor roots		
		3	movement by client		
		3	client overwatering		
		1	humidity too low		

[1] Ranking system is explained in the text (p. 11).

D. PEST MANAGEMENT IN INTERIOR LANDSCAPES

The following discusses pest management in interior landscapes, with particular reference to Vancouver, B.C., using the literature and questionnaire data.

I. Identification of pest problems

The questionnaires have a number of questions which deal with pest problems, each with a slightly different slant. Question M:21/E:9 deals with the frequency of pest occurrences, M:22/E:10 with the length of time they have been a problem, while M:23/E:13 identifies which ones are difficult to control. Question M:23/E:11 tries to correlate plants with pests in order to see if any particular plant is particularly prone to pest problems. How each pest is controlled (M:24/E:12) will be dealt with in the next section.

Interesting results come from question M:21/E:9, which is concerned with the frequency of pest occurrence. Ranking was similarly determined as in the previous table. Respondents were asked to check the percentage range in which each pest fell. Ranks were given to each percentage range, i.e., '0' for 0%, '1' for 1–9%, '2' for 10–19%, etc. These ranks were then summed for each pest group and are shown in table 4.

Differences of opinion are found between the respondent groups, however mites were ranked number one by all. Scales were ranked second by maintenance managers, fourth by non-maintenance managers, and eighth by the employees. Maintenance managers were the only group which considered whiteflies to be a problem and ranked them fourth. Employees, on the other hand, considered thrips and root rot to be more of a problem, and ranked them third and fourth; while maintenance managers ranked them ninth and eighth. Root rot was not considered a problem by the non-maintenance managers; thrips were lowest (seventh) on their list.

Table 4. Ranking of pest problems according to frequency of occurrence (Question M:21/E:9).

RANK[1]	EMPLOYEE	RANK[1]	MAINTENANCE MANAGER	RANK[1]	NON MAINTENANCE MANAGER
64[2]	mites	30	mites	9	mites
16	aphids	21	scales	6	fungus gnats
16	thrips	17	aphids	4	mealybugs
14	root rot	13	whiteflies	3	scales
12	fungus gnats	9	fungus gnats	3	aphids
10	powdery mildew	8	mealybugs	2	powdery mildew
9	mealybugs	7	powdery mildew	2	thrips
7	scales	6	root rot	0	root rot
5	stem rot	3	thrips	0	stem rot
3	weevils	3	stem rot	0	whiteflies
1	slugs	1	ants		
1	ants	1	centi-pedes		
1	coffee				
0	whiteflies				

[1] Ranking is explained in the text (p. 13).

[2] Combined value for 'mites' (48) and 'false mites' (16).

Table 5. Comparison between length of time employed and ranking of root rot (Questions M:1,21/E:1,9).

EMPLOYEE		MAINTENANCE MANAGER		NON MAINTENANCE MANAGER	
RANKING[1] OF ROOT ROT	LENGTH OF TIME EMPLOYED	RANKING[1] OF ROOT ROT	LENGTH OF TIME EMPLOYED	RANKING[1] OF ROOT ROT	LENGTH OF TIME EMPLOYED
4	2y 8m	3	33y 0m	0	4y 6m
3	5	1	1 1	-	7
2	4	1	2	-	8
2	√[2]	1	5	-	14
1	√[2]	10/13[3]	8 3		
1	5	-	4		
1	3	-	6		
0	6	0	8		
-	10	0	10		
		-	10		

[1] Dashes (-) indicate no response was given to the category root rot, and is therefore presumed to be zero. Ranking was determined as in the previous table.

[2] Checkmarks (√) were the actual responses given.

[3] Respondent ranked root rot as tenth in a list of 13.

Reasons for these differences between groups are unclear except perhaps for root rot, which is usually a result of overwatering, and is one of the common problems a plant maintenance person must learn. Excess water in the potting medium reduces the amount of oxygen, which the roots need to survive. The dead and dying roots are invaded by root rot organisms, such as phycomycetes. Reduction in the amount of roots reduces the amount of water which can be absorbed and transpired, hence the plant wilts (Henley & Poole 1981). An interesting (and logical) trend can be observed between the rank of root rot as a problem and the length of time the respondent has been employed in the industry. Among the employees, the one who has worked the least amount of time (2 years 8 months) ranked root rot the highest (4). The two employees who have worked the longest (6 & 10 years) ranked root rot as a zero or no response. The other employees fell in between these extremes (table 5).

This trend can also be seen among the maintenance managers. Three managers (working 1, 2, & 5 years) ranked root rot as a one. The others (working 6, 8, & 10 years) ranked it a zero. Two anomalies show up; one manager having worked 33 years ranked root rot a three, another manager working 8 years 3 months ranked it tenth out of a list of thirteen. This manager did not estimate percentages.

In trying to determine if certain pest problems were longstanding or recent (question M:22/E:10), the responses were generally split. Four employees and five managers[4] said that these problems had not changed over time; whereas four other employees and seven other managers[5] said that they had.

Employees as a group are split as to which pests represent old and which represent new problems. Mites, scales, thrips, and false mites are pests that are now under better control for some employees, while for others the same pests are not under better control now. Mealybugs were considered by two employees to be under better control now.

Managers, however, agree as to which are old problems and which are new problems. For this group mites, scales, aphids, and mealybugs are now less of a problem; while thrips, whiteflies, leafminers, weevils, and false mites have become more of a problem recently.

Results from question M:23/E:11 identify particular plant-pest associations which are more prevalent or troublesome. Table 6 lists the plant-pest associations which

---

[4] Four maintenance managers and one non-maintenance manager.

[5] Four maintenance and three non-maintenance managers.

Table 6. Plant-pest associations mentioned more than once (Question M:23/E:11).[1]

NUMBER OF RESPONSES	PLANT	PEST
a) EMPLOYEE[2]		
5	*Dracaena marginata*	false mite
5	*Cissus rhombifolia*	powdery mildew
4	*Ficus benjamina*	mite
3	*Dracaena marginata*	root rot
3	ferns	scale
2	*Chrysalidocarpus lutescens*	mite
2	*Dracaena marginata*	mite
2	*Ficus retusa nitida*	mite
2	*Aglaonema*	mealybug
2	*Brassaia actinophylla*	scale
b) MAINTENANCE MANAGER[3]		
4	*Brassaia actinophylla*	mite
4	*Chrysalidocarpus lutescens*	mite
2	*Dracaena marginata*	mite
2	*Ficus* spp.	scale
c) NON-MAINTENANCE MANAGER[4]		
2	*Brassaia actinophylla*	mite
2	palms	mite
2	*Ficus retusa nitida*	scale

[1] see Appendix D for the common names of plants.

[2] total number of associations=29, number of respondents=9.

[3] total number of associations=36, number of respondents=7.

[4] total number of associations=11, number of respondents=3.

Table 7. Ranking of pest problems according to difficulty of control (Question M:25/E:13).

NUMBER OF RESPONSES	EMPLOYEE	NUMBER OF RESPONSES	MAINTENANCE MANAGER	NUMBER OF RESPONSES	NON MAINTENANCE MANAGER
7[1]	mites	6[2]	mites	2	mites
5	scales	3	scales	2	aphids
4	thrips	2	aphids	1	mealybugs
2	aphids	2	mealybugs	1	scales
1	weevils	2	whiteflies	1	thrips
1	root mealybug	1	fungus gnats		
		1	powdery mildew		
		1	root rot		
		1	fungus		

[1] combined value for 'mites' (4) and 'false mites' (3).

[2] combined value for 'mites' (5) and 'false mites' (1).

were mentioned more than once. The plant-pest associations mentioned by maintenance and non-maintenance managers are more similar to each other than associations mentioned by the employees and either of the manager groups.

Table 7 shows which pests are considered to be difficult to control (question M:25/E:13). The respondents were not asked to rank the pest according to difficulty, thus the table shows only the accumulated number of responses for each pest category. Mites were the most frequently mentioned by all three groups; but aphids also tied for first place with non-maintenance managers. Scales were second most frequently mentioned; however with non-maintenance managers mealybugs and thrips were also second most frequently mentioned. Thrips were third most frequently mentioned by employees, and not mentioned at all by maintenance managers.

II. Approaches to pest problems

When it comes to solving a pest problem on interior foliage the maintenance person generally has three options; 1) replace the plant and forget about any attempt at pest population reduction; 2) reduce the population *in situ*; or 3) reduce the population in the greenhouse. The first option is the easiest but also can be the most expensive. Thus the second and third options are preferable economically.

The following management methods will combine information from the questionnaire and from the literature. The literature provided both recommendations for use (in Canada and the USA) and efficacy trials on various pesticides. Most of the pesticide trials, either for greenhouse or non-greenhouse use, were conducted in the USA; and not all of those tested are registered for use on ornamental plants in interiors in either country.

Pesticide products registered in Canada are classified into one of four classes: domestic, commercial, restricted, and manufacturing (Canada 1978). The use for which the product is intended is the primary consideration in classifying pest control products. Domestic class products are intended "for use in and around a dwelling", commercial class products are for "general use in commercial activities specified on the label". The intent of the restricted category is to limit the availability of extremely hazardous products to situations where they can be used safely. The manufacturing category is for products containing "registered active ingredients ... for use in manufacturing, formulating or repacking" (Agriculture Canada 1984, p. 6). Besides the primary consideration of use, "secondary toxicological, environmental and packaging criteria" have been established for each of the first three categories. For example, domestic class products must have an acute oral LD_{50} over 500 mg/kg, commercial class products must have an acute oral LD_{50} over 50 mg/kg, and restricted class products must have an acute oral LD_{50} less than 50 mg/kg. Registered control products can only be classified into one of these categories.

In general, pesticide products available for use in interior landscapes in Canada are either commercial class products labelled specifically for use in interior plantscapes (of which I have only found one), or domestic class products labelled for use on ornamental plants indoors.

The responses to question M:24/E:12, which deals with control methods, are summarized in tables 8–10. The pests are arranged alphabetically in two groups; the first group are the pests named in the question, the second group is the responses to the 'others' option. The control methods are arranged in decreasing order of total number of responses. The last column, headed 'OTHERS', is generally a collection of methods which were used by only one respondent for one pest; Pentac and Lannate in table 9 are the exceptions due to space.

The most frequently used control method overall was Safer's® Insecticidal Soap (total count: 34 employees, 49 managers). Replacing the plant was the next most commonly used control method (total count: 23 employees, 36 managers). A number of respondents used a variety of control methods, which were tried in sequence if the previous control method was unsuccessful.

The next frequent choices of control methods, after Safer's® and replacing the plant, differ with each group. Managers tended to prefer chemicals over the non-chemical methods chosen by the employees. In addition, it is interesting to note that more employee respondents had their applicator's licence (7 out of 9) than managers (5 out of 14)(M:6/E:2). Perhaps the process of obtaining the licence informs the individual of other methods of control, as well as emphasizes the potential dangers of pesticide use.

When asked if the respondent felt that the control methods available were adequate (M:13/E:15), responses were generally split, but they tended to lean to the

Table 8. Control methods used by employees (Question M:24/E:12).

	TOTAL NUMBER OF RESPONSES	SAFER'S	REPLACE	IMPROVE WATER-ING	REMOVE AFFECTED PARTS	PICK OFF BUGS	DIAZINON	VAPONA	FUNGICIDE DRENCH	PENTAC	OXYGEN PLUS	OTHERS
aphids	7	5	1	-	3	-	-	-	-	-	-	diatomaceous earth
fungus gnats	7	1	1	2	-	-	4	1	-	-	-	
mealybugs	9	7	4	-	-	-	-	-	-	-	-	
mites	9	9	1	-	-	-	-	-	-	2	-	
powdery mildew	6	1	2	4	3	-	-	-	-	-	-	benomyl, fungicide
root rot	8	1	5	3	-	-	-	-	2	-	1	
scales	7	4	3	-	1	4	-	1	-	-	-	
stem rot	7	1	3	3	3	-	-	-	-	-	1	pyrethrum, Truban, more light
thrips	4	3	2	-	-	-	1	-	-	-	-	
whiteflies	3	2	1	1	-	-	-	-	-	-	-	parasite
false mites	0	-	-	-	-	-	-	-	-	-	-	
slugs	0	-	-	-	-	-	-	-	-	-	-	
weevils	1	-	-	-	-	1	-	-	-	-	-	weevil bait
TOTAL		34	23	13	10	5	5	2	2	2	2	

Table 9. Control methods used by maintenance managers (Question M:24/E:12).

	TOTAL NUMBER OF RESPONSES	SAFER'S	REPLACE	DIAZINON	MALATHION	PYRETHRUM	RAID	IMPROVE WATERING TECHNIQUE	REMOVE AFFECTED PARTS	FUNGICIDE DRENCH	OTHERS
aphids	9	6	2	3	1	1	1	-	-	-	
fungus gnats	5	2	2	2	1	1	-	1	-	-	
mealybugs	8	6	3	2	-	-	-	-	-	-	LANNATE, household soap
mites	9	7	2	2	1	1	-	-	-	-	CYGON, misting PENTAC
powdery mildew	5	2	2	-	-	-	-	2	-	-	fungicide, more light, CAPTAN
root rot	7	1	7	-	-	-	-	1	1	2	repot plant
scales	7	4	2	1	-	-	1	-	1	-	LANNATE, cigarette tobacco
stem rot	3	1	2	-	-	-	-	-	1	-	AGRI-STREP fixed copper
thrips	5	3	2	1	1	1	1	-	-	-	
whiteflies	4	3	1	-	1	-	1	-	-	-	
false mites	1	1	1	-	-	-	-	-	-	-	PENTAC
slugs	0	-	-	-	-	-	-	-	-	-	
weevils	2	-	-	-	-	-	-	-	-	-	VAPONA, weevil bait
TOTAL		36	26	11	5	4	4	4	3	2	

Table 10. Control methods used by non-maintenance managers (Question M:24/E:12).

	TOTAL NUMBER OF RESPONSES	SAFER'S	REPLACE	DIAZINON	LANNATE	BRAVO	RDVRAL	PENTAC	AMBUSH
aphids	2	1	1	1	-	-	-	-	-
fungus gnats	2	1	1	1	-	-	-	-	-
mealybugs	2	2	1	-	1	-	-	-	-
mites	2	2	1	-	-	-	-	1	-
powdery mildew	1	1	1	-	-	-	-	-	-
root rot	2	1	1	-	-	1	1	-	-
scales	2	2	1	-	1	-	-	-	-
stem rot	2	1	1	-	-	1	1	-	-
thrips	2	1	1	1	-	-	-	-	-
whiteflies	2	1	1	-	-	-	-	-	1
false mites	0	-	-	-	-	-	-	-	-
slugs	0	-	-	-	-	-	-	-	-
weevils	0	-	-	-	-	-	-	-	-
TOTAL		13	10	3	2	2	2	1	1

positive side (employees: 5–yes, 3–no; managers: 9–yes, 5–no).

The use of biocontrols is summarized in table 11 (questions M:14–16/E:16–18). Fifty percent of the non-maintenance managers, 12.5% of the maintenance managers, and 22% of the employees use biocontrols. Perhaps this is in keeping with data from question M:10, which tried to determine the relative use of the three basic types of planting methods. Fixed planting beds (M:10f, M:10g) offer the highest potential for use of biocontrol agents, for a number of reasons: (1) the plants are not as easily removed as when planted in moveable planters, thus removal to the greenhouse is not a possibility, or (2) pest populations are likely to be larger in fixed beds and therefore could maintain a predator population.

All of the 14 managers answered question M:10 in some form or another, however only two answered it the way I had intended (i.e. the sum of responses to 10a–10j = 100%). Six respondents split the question into three according to the general type of planter – moveable floor (M:10a–e), hanging basket (M:10h–j), and fixed bed (M:10f–g). Within these groups percentages were given that added to 100%. The remaining six respondents gave checkmarks only, no percentages were given at all.

As the fixed–bed type offers the highest potential use of biocontrols, the 6 who did not use this type would therefore not be large potential users of biocontrols. Of the remaining eight who used fixed–bed planters, only two established percentages based on all types of planters. In one case, the fixed–bed type forms only 2% of the planters used, while for the other the figure is 50%. The latter would be expected to be a higher potential user of biocontrols. However, this particular respondent tried only *Encarsia formosa* Gahan (Hymenoptera: Encyrtidae) (greenhouse whitefly parasite) as a biocontrol agent and did not continue with its use. He states his reasons: "We seldom deal with an environment [, but] usually [only] individual plants. To clients a bug is a bug harmful or beneficial" [*sic*]. These statements are inconsistent with his response from question M:10, i.e., that 50% are potted in fixed beds. In my experience, fixed–bed planters always have more than one plant, and often with ground cover. To me, this would constitute an environment. In addition, *E. formosa*

Table 11. The use of biocontrols by the respondents (Question M:14-16/E:16-18).

RESPONSES	EMPLOYEE	MAINTENANCE MANAGER	NON MAINTENANCE MANAGER
number (%) never tried biocontrols:	7 (77%)	7 (87.5%)	3 (50%)
number (%) has tried biocontrols:	2 (22%)	1 (12.5%)	3 (50%)
biocontrols used for?:	2 mites 1 aphids	1 mites 1 mealybugs	2 mites 2 whiteflies 1 scales
number of respondents continuing use:	1	1	2
discontinued use on:	aphids		

[1] numbers indicate number of responses.

is roughly the size of a spider mite (Steiner & Elliott 1983), i.e., it is virtually invisible, and thus 'a bug is a bug ...' sentiment is confusing.

1. Physiological problems

The literature and questionnaire reveal that physiological problems (poor light in particular, table 3) are more common than pests. It is also a common problem in production. In 1976 a clinic was set up in Florida by Extension personnel at the Agriculture Research Centre, Apopka, Florida, to assist growers with their production problems. Over a five year period the number of grower visits declined, which translated to an approximate 50% decrease in the number of problems identified.

Most of these problems were identified as cultural, which increased over the five year period, while the number of organism-related problems declined. The authors (Barmby & Pate 1979, 1981; Barmby *et al.* 1977) claimed the clinic was successful in educating the growers and thus they were able to diagnose and treat many of the common problems. The authors' reasons for the decrease in number of problems assumes that the clinic was successful.

2. Pathological problems

Plants used for interior landscaping are susceptible to many diseases (Furuta 1983). Leaf spots, stem cankers, and stem and root diseases are common examples. Chase (1985) has compiled a list of diseases for common interior foliage plants. Out of 54 plant groups, all but 7 have more than 2 diseases listed. *Dieffenbachia* spp., for example, has 17 listed. "Under interior conditions, it is often impossible to cure a disease; the only practical solution is to remove or replace the plant" (Furuta 1983, p119). With this in mind, plus the greater difficulty in identifying the causal organism, diseases of indoor foliage plants will not be discussed in this paper.

3. Entomological problems

Arthropod problems are more easily identified and potentially easier to control than the previously mentioned problems. The following sections describe life histories, types of damage and symptoms, management strategies, etc. of pests commonly found in interior plantscapes.

Each section contains a table (tables 12-19) which presents pesticide information pertinent to that pest group. Briefly, each table lists the pesticides (by active ingredient) which are registered for controlling the specific pest group on ornamentals. In addition to showing the class(es) of registration, those recommended for use and those used by the respondents are also shown.

The following is a more detailed explanation of what information these tables present and how that information was derived.

Registration

In Canada all pest control products must be registered; the government department mainly responsible for this is Agriculture Canada. Each pest control product has a particular class of registration (see page 19 for further explanation). Products may only be used in certain locations according to the label, e.g., greenhouse, home. In most cases, domestic class products are for use in and around the home, and do not require an applicator licence. In comparison, commercial class products (those referred to in this paper) are normally for use in greenhouses; however, these are not mutually exclusive categories. There are some domestic class products for use in greenhouses, and some commercial class products for use in the home. This would allow any person in the greenhouse to control some pest situations, and would allow the use of more toxic chemicals in the home (requiring a licenced person to apply them).

Categorization

Pesticides division, Agriculture Canada, (now Pesticides Directorate) is preparing a database containing information on all pest control products registered in Canada. The location(s) of where pest control products may be used has been categorized and coded. For the purposes of this paper it would have been convenient if there had been a category for interior landscapes. The categories I expected to contain the pest control products which could be used on foliage plants in interior situations were: ornamentals in the greenhouse (ORG) and ornamentals in the home (ORH). The 'ORG' category also includes many flowering and bedding plants, and similarly, 'ORH' includes other plants not used in interior landscapes. As well, both categories contain products for control of pests not found in interior landscapes.

Registration

From this database, the pest control products that had the ORG and ORH location codes were selected. The resulting lists were examined. Pest control products registered for control of those pest groups discussed in this paper and for use on typical plants found in interior landscapes were compiled and presented. However, the database was not complete at the time of the search (June 1984) and accuracy of the data could not be guaranteed. Therefore, the data were then checked against: (1) *Compendium of Pest Control Products Registered in Canada* (vols. RP & IN)(Scott 1984*a*, Scott 1984*b*), and (2) *Pest Control Products Registered in Canada*, a microfiche set which contains all the pesticide labels of pest control products registered in Canada (Icon Micrographics 1984). This resulted in the list of pesticides found in each table (tables 9–16). The registration class of pest control products containing these active ingredients are presented under the heading 'Registration'.

Recommendation

The above lists presumably include all pesticides that can be used in interior landscapes. Since the information is somewhat difficult to extract, I searched for more accessible sources of information on pesticides. The following publications filled this criterion: *Greenhouse Ornamental and Bedding Plant Pest Control Guide - 1984* (BCMAF 1984), *Pest Control in the Home and Garden* (BCMAF 1982), *Biological Pest Management for Interior Plantscapes* (Steiner & Elliott 1983), and *Pest Problems in Small Greenhouses and Indoor Plantings*, (Tonks *et al.* 1982).

As mentioned before, pest control products are registered for use in certain locations, e.g., greenhouse or home. These publications provide pesticide use recommendations for pest problems on ornamental plants and each of these is directed to one location (i.e., greenhouse, BCMAF 1984; home, BCMAF 1982, Tonks *et al*. 1982; and interior landscape, Steiner & Elliott 1983). Data presented under the heading 'Recommendation' show which pesticides are recommended by these authors. Recommendations for home use are directed at people who have no applicator licence and therefore are only allowed to use domestic class products. The separation of registration class (under the heading 'Registration') and the location of use or target group of people (under the heading 'Recommendation') serves to check whether there actually are products registered for the recommended use. This proved to be the case in a number of instances.

Application

Tables 12 to 19 list the pesticides alphabetically according to the common name of their active ingredient. Respondents cited both common names and trade names when answering the questionnaire (tables 8–10). Thus, responses like Raid®, for example, will be included under pyrethrins, its active ingedient (table 13).

a. Aphids (Homoptera: Aphididae)

There are a number of species of aphids which can attack tropical foliage plants. The more common ones are: green peach aphid, *Myzus persicae* (Sulzer); spirea aphid, *Aphis citricola* van der Goot; cotton or melon aphid, *Aphis gossypii* Glover; and cowpea aphid, *Aphis craccivora* Koch (Hamlen *et al*. 1981). Typical susceptible plants are: *Aphelandra*, *Brassaia*, *Dieffenbachia*, *Gynura*, and *Hoya*.

Aphids are small (about 3mm), delicate, pear-shaped insects. Their colour can be green, brown, red or black, depending on the species. Under indoor conditions, reproduction is by parthenogenesis. Adult females produce about 50 nymphs throughout their lifespan. In about 7 days the new adults are reproducing.

Adults and nymphs feed with piercing-sucking mouthparts, usually preferring young shoots and leaves, while some species prefer flowers, twigs and branches. Distorted or stunted growth is the typical injury. A by-product of feeding is honeydew, which covers the foliage beneath the aphids and can serve as a growth medium for sooty mold fungi.

The pesticides recommended for home use indoors are: diazinon, malathion, pyrethrin, rotenone, and Safer's®. Diazinon, however, is only registered for control of aphids on ornamentals outdoors. Pesticide registration, recommendation and use is summarized in table 12. Biocontrol agents, such as ladybird beetles, *Chrysopa*, and *Aphidoletus*, are also recommended (Steiner & Elliott 1983). One respondent has used biocontrol agents for aphids, but no longer does (table 11). No reason was given for

Table 12. Chemicals registered, recommended, and used by respondents for control of aphids.[1]

PESTICIDE	REGISTRATION[2]	RECOMMENDATION[2]	USED BY: EMPLOYEE	USED BY: MAINTENANCE MANAGER	USED BY: NON MAINTENANCE MANAGER
acephate	C	G			
allethrin	D				
d-trans - allethrin	D				
demeton	C R				
diazinon	C	H		3	1
dichlorvos	C	G			
dienochlor	D				
endosulfan	C	G			
kinoprene	C	G I			
lindane	C				
malathion	D C	H		1	
methoxychlor	D				
methoprene	D				
naled	C	G			
nicotine	C	G			
oxydemeton-methyl	C				
parathion	R	G			
pirimicarb	C	G			
pyrethrins	D	H		2	
resmethrin	D C				
rotenone	D	H			
soap	D C	H G I	5	6	1
sulfotep	C	G			
tetradifon	C				
tetramethrin	D C				

[1] See text for explanation (p. 26).

[2] D=domestic, C=commercial, R=restricted, H=home, G=greenhouse, I=interior landscape.

having discontinued their use, nor was the identity of the agent given.

Of the recommended list of 5 pesticides for domestic home use (table 12), four were used by the maintenance managers, two by non-maintenance managers, and one by the employees (see also tables 8-10). One employee tried diatomaceous earth for aphid management. Two active ingredients have been found formulated with diatomaceous earth, pyrethrins and rotenone. Fossil Flower Natural Bug Killer for Vegetables (PCP #15899) contains rotenone and is registered for use on flowering plants in the home and garden. Diacide Natural Insecticide Powder (PCP #14073) contains pyrethrins and is registered for certain aphids on plants 'in the conservatory or garden'. The response 'diatomaceous earth' was not included in the table due to uncertainty about which active ingredient was used.

Two trials in the USA (Hamlen 1976, Hamlen & Henley 1977) supplied data on Raid® House and Garden Bug Killer and i-Bomb® (Raid is one of the strategies used by respondents). Products with these names are registered in Canada and the USA. Table 13 show the differences in contents. Both products were tested against *Myzus persicae* on *Aphelandra squarrosa* Nees (zebra plant). Both were effective 5 and 28 days post-initial treatment. One treatment and three treatments, 7 days apart, were equally effective.

Other trials tested acephate, butocarboxim, butoxycarboxim (Oetting 1982), dichlorvos (Hamlen & Henley 1977), and a mixture of methoprene, cycloprate and resmethrin (Hamlen 1977*b*). All reduced *M. persicae* populations, however only the first three applied as systemics provided a sustained control. Retreatments were required with the remaining two.

Butoxycarboxim darts originated in West Germany by Wacker-Chemie GmbH (Worthing 1979, Vulić & Bräunling 1974) and offer a very neat management method. The paper dart, impregnated with butoxycarboxim, is inserted into the soil. The active ingredient is then released by moisture, taken up by the roots, and distributed within the plant systemically. For maintenance personnel, this would be a handy option for aphid control, less messy than sprays, drenches, granules, etc. One possible disadvantage, as revealed by Oetting (1982), is the time factor. It took 7 days before

Table 13. Contents of Raid® and i-Bomb®

INGREDIENT	RAID® USA	RAID® CANADA[1]	i-Bomb® USA	i-Bomb® CANADA[2]
pyrethrin	0.25%	0.25%	0.0255%	0.025%
piperonyl butoxide	1.05%	1.25%	0.256%	0.256%
rotenone			0.128%	0.128%
other Cubé extractives			0.236%	
petroleum distillate	1.0%			
petroleum hydrocarbons			0.102%	

[1]PCP #9749: Raid® House and Garden Bug Killer.

[2]PCP #16206: Plant Marvel i-Bomb® Insecticide Spray.

an effect was noticed with the butoxycarboxim darts, whereas only 3 days were necessary before an effect was noticed with a soil drench of butocarboxim. Whether or not this time difference is important will depend, in part, on how quickly the client likes action to be taken. A combination of darts and a spray to knockdown the population might be useful in this respect.

Pesticides recommended for commercial use (BCMAF 1984) are shown in table 12. Kinoprene (Enstar®) is recommended when biocontrol agents are in use. However, it is not effective against *Myzus persicae* but can be against other aphid species.

b. Fungus gnats (Diptera: Sciaridae)

Fungus gnats, usually species of the genus *Bradysia*, are about 3 mm long, black, with a delicate pair of wings. They are weak fliers and are commonly observed running on the soil surface. At 22°C, adult females live only about a week and produce from 75 to 200 microscopic eggs in soil crevices. Hatching occurs in 4-6 days. Larvae are legless, slender, white with a black head capsule, grow to 6mm, and live in the soil. There are 4 larval stages and development lasts 2-3 weeks. The pupal stage is 5-6 days long. The pupae usually work their way to the soil surface before emerging as adults (Hungerford 1916, Steffan 1966). In total the egg to egg generation time is 21-33 days.

Adults are the visible pest and can be the source of complaints from clients. The larvae, however, are usually the ones actually damaging the plant. Although the larvae of many species are saprophagous, feeding on decaying plant material, a few species are associated with feeding and decay of plant roots, root hairs and lower stem tissues. Larval feeding can predispose a plant to fungal attack. Conditions favourable for fungus gnats are moist soils with a high organic content (Hamlen & Wettstein 1978).

The most effective control strategy (BCMAF 1982) is to remove the soil from the plant, thoroughly wash the roots and repot the plant in sterilized soil. As well, watering should be reduced, since fungus gnats prefer moist soils. The recommended domestic pesticides are malathion (BCMAF 1982, Tonks *et al.* 1982) and diazinon (Tonks *et al.* 1982). Both applications are soil drenches. In trials for indoor use, using *B. coprophila*, Hungerford (1916) found that covering the pot with sand and watering from below reduced fungus gnat populations. The sand is unattractive for egg-laying and prevents any larvae that hatch from getting down to the soil. Pupae already in the soil also have trouble getting through this dry sand layer.

The methods used by the maintenance managers include the recommended methods plus Safer's and pyrethrum. Non-maintenance managers use Safer's and diazinon; while employees use Safer's, diazinon, and Vapona (=dichlorvos). Table 14 summarizes this information. No registered product containing soap could be found for control of fungus gnats in any location or on any host. Products containing dichlorvos and pyrethrins were found for use only on mushroom soils or empty mushroom houses.

Vickie Allesia, of Van Herrick's Environmental Planting, Burnaby, B.C., states in a letter to Interior Plantscape Association's <u>News For You</u> (June 1985) that this year fungus gnats are a "number one pain". Her methods of approach to the fungus gnat problem were as follows:

Table 14. Chemicals registered, recommended, and used by respondents for control of fungus gnats.[1]

PESTICIDE	REGI-STRATION[2]	RECOM-MENDATION[2]	USED BY EMPLOYEE	USED BY MAINTENANCE MANAGER	USED BY NON MAINTENANCE MANAGER
diazinon	D	H G	4	2	1
dichlorvos			1		
kinoprene	C				
malathion	C[3]	H		1	
pyrethrins				1	
soap			1	2	1

[1] See text for explanation (p. 26).

[2] D=domestic, C=commercial, H=home, G=greenhouse.

[3] PCP #8624 - label states: aphids, mites, mealybugs, thrips, etc.

"Solution number one is granular diazinon applied to the soil and watered in. In the past years for isolated outbreaks this has solved the problem. Not this year.

Solution number two: dry out the soil mix. Result— wilted plants and the bugs are still flying.

Solution number three: the soil drench. So far we have worked through Diazinon 500 E.C., Basudin 50% W.P. and Malathion 50 E.C. The only real success was with Malathion and the draw-back here was a lingering 'gasoline' smell for weeks after the application. After consultation with the manufacturer of the chemical, lime was applied to the soil. Success at last! No gnats and no smell.

Solution number four was addressed as well— a discussion with our supplier about the advisability of treating the problem at the greenhouse level where it seems to originate."

Removal of plants to the greenhouse for treatment is a possibility. However, only diazinon is recommended (BCMAF 1984) for commercial use (at the same rate as domestic use).

Greenhouse trials conducted by Hamlen & Mead (1979) found acephate, aldicarb, carbofuran, isazophos, diazinon, and oxamyl to reduce levels of *Bradysia impatiens*

(Johannsen) for the length of the trial (35 days). Trials using *Bradysia coprophila* (Lintner), the house plant gnat, found kinoprene and methoprene effective, while acephate, chlorpyrifos, methomyl, permethrin, and resmethrin gave "satisfactory control" within one week.

c. Mealybugs (Homoptera: Pseudococcidae)

There are quite a number of mealybugs that attack foliage plants. Some feed on leaves and above ground parts, while others feed on roots. Typical foliar mealybugs are: long-tailed mealybug, *Pseudococcus longispinus* (Targ.-Tozz.); grape mealybug, *P. maritimus* (Ehrhorn); citrophilus mealybug, *P. calceolariae* (Maskell); solanum mealybug, *Phenacoccus solani* Ferris; Mexican mealybug, *P. gossypii* Townsend and Cockerell; striped mealybug, *Ferrisia virgata* (Cockerell); coconut mealybug, *Nipaecoccus nipae* (Maskell); and citrus mealybug, *Planococcus citri* (Risso). Root mealybugs are usually of the genera *Rhizoecus* or *Geococcus*.

Adult female, foliar mealybugs are soft bodied insects, 3-5mm long, slow moving, and elongate oval in shape. They are usually covered with a white, mealy or cottony wax secretion and often possess waxy filaments which protrude from the sides of the bodies. Root mealybugs are similar to foliar mealybugs except that the adult females have no filaments and are only about 3mm in length. Adult males of all species are tiny, winged, gnat-like, live only for a few days, and do not feed (Barclay & Koehler 1980).

Several species reproduce parthenogenetically (e.g. *Planococcus citri*, *Ferrisia virgata*) (MacKenzie 1967, Highland 1956). The eggs, 100-300 in number, are contained within an egg sac composed of secretions produced by the female. The eggs hatch in 5-10 days. *Pseudococcus longispinus* and *Phenacoccus solani*, however, produce live nymphs, the eggs hatching inside the female (MacKenzie 1967).

Females pass through 3 larval instars, while males pass through 4. The immature female stages feed for about 6-8 weeks before becoming adults. Males form a small cottony coccoon 2-3 weeks after hatching, and emerge as winged adults 7-10 days later (Barclay & Koehler 1980). (As strange as it may seem, the female's development time is twice as long as that of the male). The first instar is called the crawler stage, which is quite mobile and is the stage which disperses.

Generation times of root mealybugs are much longer than those of foliar mealybugs. For example, the egg to egg generation time of *Rhizoecus americanus* (Hambleton) is 42–50 days, and that of *Rhizoecus pritchardi* McKenzie is 2–4 months. It can often take 3–6 months before populations become easily detectable.

Mealybugs tend to cluster in large numbers and feed with piercing-sucking mouth parts. The loss of plant sap to the mealybugs reduces the vigour of the plant, which may become chlorotic, stunted, or killed, depending on the size of the colony. A few species inject toxins (e.g. *P. longispinus*) or transmit viruses which can seriously damage the host plant although very few insects are present (Barclay & Koehler 1980). Mealybugs produce honeydew which can be a substrate for sooty mold growth.

Mealybugs can be difficult to control due to their tendency to cluster together in protected areas of the plant, i.e., leaf axils, cracks and crevices in the bark, the undersides of leaves, etc. The waxy secretions covering the insects and egg masses afford some protection from insecticides (Barclay & Koehler 1980).

The recommended management methods are: dislodging the mealybugs by hosing down the plants frequently or choosing plants least susceptible to damage and infestation (Steiner & Elliott 1983). The former is impossible in almost all interior situations and the latter, in the words of one respondent, "if we stopped using our plants we'd end up out of business" [*sic*].

Biocontrol agents, such as *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae), *Chrysopa carnea* Stephens (Neuroptera: Chrysopidae), and *Leptomastix dactylopii* Howard (Hymenoptera: Encyrtidae) offer possible avenues for controlling foliar species. Only one respondent (maintenance manager) uses biocontrol agents against mealybugs; and another would "if they were available to us". *L. dactylopii* is the best, but is in limited supply (D. Elliott, personal communication).

Lindquist (1981*a*) released *C. montrouzieri* for mealybug control in an interior planting. In the first experiment adults were released, many of which did not remain on the plants; no control was achieved. In a second experiment, larvae were released. They reduced populations but did not come close to eliminating them. Lindquist does not consider *C. montrouzieri* to be very effective and is testing other predators.

Table 15 summarizes pesticide information relating to mealybugs on interior foliage plants. The recommended pesticides for home use (Tonks *et al.* 1982, BCMAF 1982) are: diazinon, malathion, pyrethrum, rotenone, and Safer's®. The only registered domestic use of diazinon that could be found was a 2% dust formulation for control of soil insects, such as fungus gnat larvae and springtails. Depending on the wording of the label, root mealybugs might be included. The methods actually used by the respondents (tables 8–10, 15) are: Safer's® only by employees; diazinon, Lannate® (=methomyl), "household soap" and Safer's® by maintenance managers; and methomyl and Safer's® by non-maintenance managers. There is no domestic registration for methomyl (as of Jan. 1, 1984, Scott 1984*b*), and no registered (commercial or restricted) use for control of scales on any plant could be found.

In a trial testing insecticides for interior use (Parella 1980*a*), acephate achieved the highest percentage reduction in *Planococcus citri* populations after 14 days (92.4%). The other chemicals tested, with decreasing efficacy, were: butocarboxim (80.4%), methoprene(?)[6] (74.5%), BAY SIR 8514 (69.2%), butoxycarboxim (65.3%), diflubenzuron (57.4%), and Safer's® (49.7%).

Another trial (Lindquist 1981*b*) tested Enstar® (kinoprene) and Zoecon Houseplant mist (kinoprene+resmethrin) against *Planococcus citri* on *Dieffenbachia* and *Brassaia*. Applications were done three times at 14 day intervals on *Dieffenbachia* and at 7 day intervals on *Brassaia*. Both were effective in reducing populations. Only kinoprene was effective in eliminating populations to zero on *Dieffenbachia* 5 weeks post initial treatment. Unfortunately, the data do not allow one to conclude whether the reduction is due to the interval between applications, to the host plant, or to chance.

Pesticide recommendations for greenhouses in British Columbia (BCMAF 1984) are: chlorpyrifos, malathion, parathion, and Safer's®.

----

[6] the text says methoprene, however, the table says kinoprene. These are different chemicals.

Table 15. Chemicals registered, recommended, and used by respondents for control of mealybugs.[1]

PESTICIDE	REGISTRATION[2]	RECOMMENDATION[2]	USED BY: EMPLOYEE	USED BY: MAINTENANCE MANAGER	USED BY: NON MAINTENANCE MANAGER
acephate	C				
chlorpyrifos	C	G			
demeton	C R				
diazinon		H		2	
dichlorvos	C				
dienochlor	D				
kinoprene	C	I			
malathion	D C	H G			
methomyl				1	1
methoprene	D				
naled	C				
parathion	R	G			
pyrethrins	D	H			
resmethrin	D				
rotenone	D	H			
soap	D C	H G I	7	7[3]	2
sulfotep	C R				

[1] See text for explanation (p. 26).

[2] D=domestic, C=commercial, R=restricted, H=home, G=greenhouse, I=interior landscape.

[3] Includes Safer's (6) and 'household soap' (1).

Insect growth regulators (IGR's) are very promising for effective control of coccoids (Miller & Kosztarab 1979). In a greenhouse trial (Hamlen 1975*b*), four different IGR's were tested against *Phenacoccus solani* on *Gynura aurantiaca*. Hamlen says all four reduced populations. However if one looks at the data, only kinoprene actually reduced initial populations. The others (hydroprene, triprene, Hoffman-La Roche Ro 20-3600) contained initial populations while the control population increased. The same chemicals were tested against *Pseudococcus longispinus* on *Ardisia*. Three applications kept numbers lower than one application, and at roughly the same initial pretreatment numbers.

Chandler (1980) tested the effect of five pesticides, diazinon, oxamyl, butocarboxim, malathion and acephate, against *Planococcus citri* on a few foliage plants. All eventually had an effect on the population but differences occurred depending on the species of host plant used. Diazinon treatments were applied at 30, 60, 120, or 240g ai/100ℓ three times, the latter two times were applied at 7 and 21 days post initial treatment. At 28 days post initial treatment, *P. citri* was eliminated on *Ficus benjamina* at all doses. Only the 240g ai/100ℓ dose eliminated *P. citri* on *Dieffenbachia* sp. 'Exotica' . Oxamyl treatments on *F. benjamina* were as above, and only one application was needed to eliminate populations. On *Dieffenbachia*, however, three applications at 60 or 240g ai/100ℓ were needed before populations were eliminated. The only other dose tested was at 30g ai/100ℓ and resulted only in suppressed populations.

One application of malathion reduced *Planococcus citri* on *Coleus* sp., *Dieffenbachia* sp. 'Exotica' and *Philodendron cordatum* (Chandler 1980). One subsequent application eliminated populations on *Coleus*, however 2 subsequent applications only resulted in continued suppression on *Dieffenbachia* and *P. cordatum*. Acephate provided better control on *Coleus* and *Dieffenbachia* 'Exotica' than on *F. benjamina*. All rates reduced populations on all plants; however, greater reduction was achieved on *Coleus* and *Dieffenbachia*. Butocarboxim eliminated *P. citri* on *P. cordatum* after three applications. Populations on *Coleus* were eliminated with three applications of butocarboxim at 240 g/100ℓ, and reduced to low levels at lower rates of application.

A variety of pesticides have been tested on root mealybugs under greenhouse conditions. Poe *et al.* (1973) tested carbaryl, malathion, monocrotophos, and diazinon against *Rhizoecus americanus* on *Chrysalidocarpus*, *Aralia*, *Chamaedorea*, *Phoenix*, *Yucca*, and *Araucaria*. At 50 days post treatment, carbaryl and monocrotophos (1 lb/100 gal) significantly reduced populations. The other two were less effective. In another trial, they tested a series of soil drenches and granular soil surface applications. The granular pesticides were less effective than drenches of the same material. Drenches of methamidophos, dimethoate, dyfonate, and diazinon eliminated populations at 14 days post treatment. All but dyfonate kept populations at zero until the end of the experiment (60 days post treatment).

d. Mites

Mites lack visible abdominal segmentation, antennae, and are generally quite small. Phytophagous mites have piercing-sucking mouthparts and feed on cellular contents. Adults have 4 pairs of legs, while larval stages have only 3 pairs. The general life history of mites has one larval stage and two nymphal instars. Within each instar there is an active period and a quiescent period just before moulting. These stages of inactivity are known as protochrysalis, deutochrysalis, and tritochrysalis (Jeppson *et al.* 1975). The major families of mites attacking interior foliage plants are the Tetranychidae (spider mites), Tenuipalpidae (false spider mites), and Tarsonemidae (cyclamen and broad mites) (Hamlen *et al.* 1981).

i. Spider mites (Acari: Tetranychidae)

Tetranychids are the most common and most destructive mites on tropical foliage. The most common species is the two-spotted spider mite, *Tetranychus urticae* Koch . Other common species are the carmine spider mite, *Tetranychus cinnabarinus* (Boisduval), and the tumid spider mite, *Tetranychus tumidus* Banks. The citrus red mite, *Panonychus citri* (McGregor), has been identified recently in interior landscapes in Western Canada. The greater use of biocontrols and the consequent decrease in the amount of spraying are the probable causes for the increase of this pest (D. Elliott, personal communication).

Adult *T. urticae* females are about 0.5mm in length, barely visible to the unaided eye; and populations can often become dense before detection. The threshold temperature of development is 12°C and the maximum developmental temperature is 40°C. The egg to egg development time varies from 36 days at 15°C to 6 days at 35°C; however the relative amount of time spent in each stage is constant (Sabelis 1981). At optimal temperatures, 30° to 32°C, the egg stage lasts 3-5 days, the female immature stages last 4-5 days, and with a preovipositional period of 1-2 days the total lifespan is 8-12 days. Fecundity of females increases with temperature and depends on the age of the female. The rate of egg production of female *T. urticae* peaks shortly after emergence and then declines. For example, the peak number of eggs produced/day/female ranges from 4 (15°C) to 20 (35°C) (Sabelis 1981).

Spider mites usually feed on the undersides of leaves, and more readily on young leaves. They feed by piercing the leaf surface and removing the cellular contents of mesophyll cells. Typical symptoms of mite infestation are a speckled appearance of the leaves as well as webbing in well-developed infestations. Severe and irreversible damage has usually occurred by the time webs have formed (Hamlen *et al.* 1981).

The recommended chemical strategies for indoor home control of spider mites is dicofol, malathion, and Safer's® (Tonks *et al.* 1982, BCMAF 1982). Employees used Safer's® and Pentac®[7] (=dienochlor) (tables 8, 16); while non-maintenance managers used Pentac® and Safer's® (tables 10, 16). Maintenance managers used diazinon, Pentac®, Cygon® (=dimethoate), malathion, pyrethrum, and Safer's® (tables 9, 16). Two pest control products were found with Cygon as part of the name (PCP nos. 10038, 10142). Both are registered for control of mites, but not on indoor foliage plants.

Predators are also recommended (Tonks *et al.* 1982, Steiner & Elliott 1983). The most frequently used is *Phytoseiulus persimilis* Athias-Henriot. Other phytoseiid mites also available are *Amblyseius californicus* (McGregor), and *Typhlodromus* (=*Metaseiulus) occidentalis* (Nesbitt). Two employee respondents have used predator mites (E:16) and one continues to use them (E:17). One of the two (E:18) found it "a much more favourable way of controlling mites; not as expensive, not a quarter of the work involved as there is when we spray, replace, etc. Also accounts [=clients] like the idea of not using chemicals or spray". The other's reasons listed were "less money, more natural, less time consuming".

One employee respondent who has never used biocontrol agents (E:16) doesn't favour them over pesticides (E:18) stating: "It's not feasible in most accounts". There are two other employee respondents who have never used biocontrol agents but do

---

[7] Pentac Aquaflow™ (PCP #17800) is one of the few pesticides that specifically states for use in interior plantscapes.

Table 16. Chemicals registered, recommended, and used by respondents for control of mites.[1]

PESTICIDE	REGISTRATION[2]	RECOMMENDATION[2]	USED BY: EMPLOYEE	USED BY: MAINTENANCE MANAGER	USED BY: NON MAINTENANCE MANAGER
d-trans - allethrin	D				
cyhexatin	C				
demeton	C R				
diazinon	C			2	
dichlorvos	C				
dicofol	D C	H G			
dienochlor	D C	G	2	1	1
dimethoate				1	
dinocap	D C				
endosulfan	C	G			
fenbutatin oxide	C	G I			
malathion	D C	H		1	
methoxychlor	D				
methoprene	D				
naled	C				
oxydemeton-methyl	C				
parathion	R				
pyrethrins	D			1	
resmethrin	D C				
rotenone	D				
soap	D C	H G I	9	7	2
sulfotep	C				
tetradifon	C	G			
tetramethrin	D C				

[1] See text for explanation (p. 26).

[2] D=domestic, C=commercial, R=restricted, H=home, G=greenhouse, I=interior landscape.

favour them. One responded:

> "It's not practical or effective to use them in a small or localized pest infestation (eg. 1 or 2 plants in an office) but they are great when you have a large insect population (to keep your predators going) or where you cannot spray for whatever reason".

The other stated:

> "In prolonged use of pesticides the new generation generally gain immunity. Also with pesticides the eggs are unkillable so unless you follow through with an expensive 3 to 4 wk program & even then not 100% sure, you're wasting time".[*sic*]

Mite predators were used by one maintenance manager and by two non-maintenance managers. The maintenance manager still continues to use predators against mites and mealybugs and favours their use because they are "better for the environment". Of the two non-maintenance managers, both continue to recommend them for mites and favour them over pesticides. One responded that the predators are "much safer and easier to use - also less expensive (labor-wise)".

There have been a number of trials reported in the literature testing the efficacy of predators in reducing spider mite populations in indoor situations. Hamlen and Poole (1980) used *Phytoseiulus macropilis* to reduce *T. urticae* populations below the damage threshold on *Dieffenbachia maculata* (Lodd.) G. Don 'Perfection'. They found that the ratio of numbers of *T. urticae* and *P. macropilis* at introduction "had a direct effect on the time required to bring about reductions in spider mite populations and maintenance of high quality plants". Predator:prey ratios of 1:5, 1:10, and 1:20 reduced populations but only ratios of 1:5 and 1:10 reduced populations to below damaging levels.

Lindquist (1981*a*) tried *Phytoseiulus persimilis* as a mite predator on plantscapes in a large suburban Cleveland motel and in two shopping malls. "*Phytoseiulus persimilis* did an excellent job of suppressing spider mites" in the motel situation. Results from the two shopping malls were mixed. Spider mite reductions were observed on croton but no predators showed up in the samples. No spider mite reduction occured on palm despite repeated predator introductions. Pesticide residues is a possible explanation given by Lindquist.

Phytoseiid predators have been used widely in greenhouses in Europe and North America on a variety of crops. Trials (Hamlen & Lindquist 1981, Hamlen 1978) have shown *P. macropilis* and *P. persimilis* to be effective in reducing *T. urticae* populations on foliage plants such as *Dieffenbachia*, *Chamaedorea*, and *Brassaia*. Results showed that control was achieved 1-3 weeks after introduction of predators if initial prey populations were low.

The literature provides some data on the efficacy of different pesticides against *T. urticae* infesting various foliage plants in indoor conditions. Safer's® was tested (Osborne 1982) using *Brassaia actinophylla* as a host plant. The author states that Safer's® is effective in reducing mite populations when used at the recommended rates, but a second application was needed to kill the remaining individuals. All stages except the eggs were counted and since the length of the trials were generally short (8-14 days), the length of time required to totally eliminate a population was not demonstrated.

Dichlorvos fumigation in polyethelene bags (Hamlen & Henley 1979) for three 12-hour durations at 7 day intervals significantly reduced populations and maintained them at barely detectable levels. Room-size fumigation with a No-Pest-Strip™ (dichlorvos) did not suppress populations.

A mixture of 0.1% methoprene, 0.07% cycloprate, and 0.05% resmethrin reduced populations by 81% and 93% on *Chamaedorea elegans* and *Dracaena sanderana* respectively. The mixture was applied twice at 14 day intervals (Hamlen 1977*a*).

Aerosol sprays[8] (Hamlen 1976) were also tested against *T. urticae* on *D. sanderana*. They were applied once or thrice at 7-day intervals. At 5 days post initial treatment, all, except for the single application of Raid®, eliminated the motile stages; eggs, however, remained. At 28 days post initial treatment all sprays, with the exception of the single application of i-Bomb®, gave 100% reduction of mites and eggs.

----

[8] i-Bomb® = see table 13,
Raid® House and Garden Bug Killer = see table 13,
Science® clover mite and red spider spray = 0.25% dicofol.

Recommended pesticides for control of *T. urticae* on ornamentals in BC greenhouses (BCMAF 1984) are: dicofol, dienochlor, fenbutatin oxide, Safer's®, and tetradifon.

Osborne (1984) concluded that Safer's® Insecticidal Soap was as effective as dienochlor for controlling *T. urticae* on *B. actinophylla* when applied at 12.4 g/ℓ. The 6.2 g/ℓ rate reduced mite populations but not to zero, which he considered to be the economic threshold level for greenhouses. Residues of Safer's® also affected the mites' choice of host plant. Soap-treated plants had fewer mites than plants which were sprayed with water only. Safer's® can also be phytotoxic depending on the dose applied and the plant treated. The 12.4 g/ℓ dose reduced plant quality significantly when applied to *Cissus rhombifolia* and *Hedera helix*. A few *B. actinophylla* also suffered some reduction in plant quality.

Dienochlor eliminated two-spotted spider mites on *Chamaedorea elegans* (Oetting & Morishita 1979) and *Dracaena* 'Red Ti' (Oetting & Morishita 1978, 1979) 2 to 4 weeks post treatment. On *Hedera* sp., *Brassaia actinophylla*, and *Dracaena sanderana* populations were reduced to 50% or less of the control populations (Lindquist 1981*c*).

ii. False spider mites (Acari: Tenuipalpidae)

False spider mites attacking foliage plants are usually of the genus *Brevipalpus*. They are smaller than spider mites and do not produce webs. A female privet mite (*Brevipalpus obovatus* Donnadieu), for example, is about 0.28mm in length and reproduces parthenogenetically. Males are very rare.

Eggs are elliptical, bright red, and hatch after about 7 days at 27°C. Larvae and nymphs are orange red with dark areas, while adult females vary in colour from light orange to dark red with various patterns of dark pigmentation. The extent of pigmentation is correlated with the host and amount of feeding (Jeppson *et al.* 1975).

The length of time spent in the immature stages varies from 11.1 days (32°C) to 26.6 (20°C), while the adult lifespan varies from 3 days (32°C) to 67 days (20°C) (Jeppson *et al.* 1975). All immature and adult stages feed, usually on the undersides of leaves, and the stems and petioles. These feeding areas will become discoloured;

faint brown flecks are the usual first sign of injury. As feeding continues these flecks will coalesce and eventually the leaves will drop off if the infestation continues.

No Canadian recommendations could be found specifically for the control of false spider mites, however under the general heading of 'mites', dicofol, malathion, and Safer's® are recommended (BCMAF 1982). In the USA (California: Allen *et al.* 1980, Florida: Short *et al.* 1984) dicofol is the only recommended pesticide for use on false spider mites in greenhouses.

In a greenhouse trial (Morishita 1954) diazinon, chlorobenzilate, and DMC gave the best control of *Brevipalpus* spp. (i.e., zero mites/leaf at three weeks post initial treatment). Aramite and ovotran reduced mites to less than 25% of the original population level and toxaphene, rotenone, and malathion to greater than 25%. Diazinon was the only organophosphate to be effective.

Pyrethrum (with rotenone) has been tested against false spider mites (Manglitz & Cory 1953) on orchids and reduced populations by 66% two days post initial treatment. Further data were not given.

iii. <u>Tarsonemid mites (Acari: Tarsonemidae)</u>

The two most important mites of this family are the cyclamen mite, *Steneotarsonemus pallidus* (Banks); and the broad mite, *Polyphagotarsonemus latus* (Banks). Recently, another species, *Steneotarsonemus furcatus* de Leon, has been found to attack foliage plants (Denmark & Nickerson 1981). Like other species of this genus, the body has undergone modifications to suit their feeding habits. Females are elongate, and both sexes are dorso-ventrally flattened which allows entry into narrow spaces, such as between the sheath and stems of monocots. Males are 166μ long and 76μ wide; females are 235μ long and 112μ wide (Denmark & Nickerson 1981).

Incubation period of cyclamen mite eggs is about 4 days at 20°C while the life cycle is usually 10–14 days. This species also reproduces parthenogenetically. High populations occur within unopened buds or between folded leaves. The foliage expanding from infested buds is curled, twisted, and brittle. Toxic substances are also produced when feeding (Hamlen *et al.* 1981).

The broad mite, *Polyphagotarsonemus latus*, another pest of ornamentals, is usually less than 0.25mm in length. The life cycle is similarly short, eggs hatch within 2-3 days under greenhouse conditions. The larvae are minute, white, pear-shaped, and live only 2-3 days. They then turn into a quiescent pupal stage (nymph) which is stuck to the underside of the leaf. This stage lasts 2-3 days (Hill 1983).

Feeding by *P. latus* occurs on lower surfaces of the newly-opened emerged leaves. Toxins are injected into the plant during feeding. This results in new leaves that are stunted, puckered, and cupped downward. New growth is inhibited under heavy infestation. Necrosis and abscission of affected plant parts follow (Jeppson *et al.* 1975).

No Canadian recommendations could be found specifically for the control of cyclamen or broad mites. However, under the general heading of 'mites'; Safer's®, dicofol, and malathion are recommended (BCMAF 1982). In the USA dicofol and endosulfan are recommended for cyclamen mites (Allen *et al.* 1980, Short *et al.* 1984). In a trial against *S. furcatus* (Denmark & Nickerson 1981) dicofol and aldicarb reduced populations but oxamyl did not.

For broad mites, dicofol and dienochlor are recommended in US greenhouses (Allen *et al.* 1980, Short *et al.* 1984). In a greenhouse trial, using *Aphelandra squarrosa* as host plant, dicofol, dienochlor, Dupont DPX 3654, oxamyl, and benomyl were tested. Two applications were made 5 days apart. At one day post initial treatment all pesticides significantly reduced mite populations. Benomyl reduced populations the least, while dicofol, dienochlor, and DPX 3654 provided the greatest reduction in mite populations. By 13 days post initial treatment, however, all pesticides had reduced populations to an equally low level.

e. <u>Scales (Homoptera: Coccidae, Diaspididae)</u>

The most common scales affecting foliage plants belong to the families Coccidae (soft or unarmoured scales) and Diaspididae (hard or armoured scales). They are closely related to the mealybugs, which are all included in the superfamily

Coccoidea.

Coccids have a rubbery outer coating which cannot be detached. Some secrete wax, but all secrete honeydew. They may be flat, oval or globular. The scale of diaspids, however, is usually not attached to the body and is composed of wax secretions and cast off skins (exuviae) of the previous instars. These scales have a variety of profiles and colours with shapes ranging from round to oyster-shell, and textures from smooth to rough. Diaspids do not secrete honeydew (Nelson 1981).

i. Diaspididae

Common armoured scales on indoor plantings are the Florida red scale, *Chrysomphalus aonidum* (L.); latania scale, *Hemiberlesia lataniae* (Signoret); fern scale, *Pinnaspis aspidistrae* (Signoret); and the false oleander scale, *Pseudaulacaspis cockerelli* (Cooley).

There are differing numbers of instars between the sexes. Females have 2 larval instars before becoming neotenic adults. Males pass through 4 immature stages, the latter two sometimes being referred to as prepupal and pupal instars, before becoming an adult (Deckle 1976). The male adult is short-lived (usually only a few hours), winged, minute, gnat-like and does not feed. The adult female remains beneath the scale and is without legs or wings (Hill 1983). Reproduction can be sexual or parthenogenetic.

Eggs are produced underneath the female shell and hatch into translucent crawlers about 0.3mm long. These crawlers, which are the only active stage not covered by a hard covering, move to new foliage, settle on or near the veins on the undersides of the leaves, and feed on the plant sap which is withdrawn by long stylets. Once diaspine crawlers are settled they begin to produce the scale. Mated females produce both sexes, parthenogenetic females only females. Diaspids can be found on any part of the plant, and commonly on leaves and stems. Their feeding can create chlorotic areas on foliage and stems. Armoured scales are often difficult to detect on bark or stems of plants.

ii. Coccidae

Common soft scales are the Japanese wax scale, *Ceroplastes ceriferus* (Fabricius); brown soft scale, *Coccus hesperidium* L.; green scale, *Coccus viridus* (Green); hemisperical scale, *Saissetia coffeae* (Walker); Mexican black scale, *Saissetia miranda* (Cockerell and Parrott); and the Caribbean black scale, *Saissetia neglecta* de Lotto (Hamlen *et al*. 1981).

Mature scales are 2-3mm long; the eggs are laid beneath the body of the mature female. *Saissetia coffeae* females can produce several hundred eggs (up to 600) (Hill 1983).

The first larval instar, called a crawler, has legs and is the major dispersal stage. It can travel for roughly 2 days in search of suitable feeding areas. *Saissetia coffeae* and *Coccus viridus* pass through 3 nymphal instars before becoming adults. Each stage becomes larger and more convex than the previous one. Nymphs can change position if conditions become unfavourable, but the adult appears to remain fixed (Hill 1983). Most species lose the legs on the first moult.

iii. Control strategies

Chemical control of scales can be difficult due to the shell like body of the females which protects both feeding scales and eggs against toxic chemicals (Hamlen *et al*. 1978). The crawler and adult male stages are susceptible. For small infestations scrubbing the scales off with a wet toothbrush is recommended (Tonks *et al*. 1982, BCMAF 1982). Table 17 shows which pesticides are registered, recommended or used by the respondents for control of scales on interior foliage plants. Employee respondents used Safer's®, and Vapona® (=dichlorvos), as well as picking the scales off the plant (table 8). Maintenance managers used diazinon, cigarette tobacco[9] Raid®, Safer's®, and removed the affected parts (table 9); while non-maintenance managers used Lannate® and Safer's® (table 10). No registered pest control product containing diazinon could be found for control of scales on ornamentals indoors.

---

[9] Most likely a tobacco "tea" which contains nicotine. Nicotine is toxic and is commercially extracted from tobacco leaves and roots by steam distillation (Hassell 1982).

Table 17. Chemicals registered, recommended, and used by respondents for control of scales.[1]

PESTICIDE	REGI-[2] STRATION	RECOM-[2] MENDATION	USED BY EMPLOYEE	USED BY MAINTENANCE MANAGER	USED BY NON MAINTENANCE MANAGER
acephate	C				
chlorpyrifos	C	G			
demeton	C R				
diazinon				1	
dichlorvos			1		
dienochlor	D				
kinoprene	C	I			
malathion	D C	H G			
methomyl				1	1
methoprene	D				
nicotine				1	
parathion		G			
pyrethrins	D			1	
resmethrin	D				
soap	D C	H G I	4	4	2
sulfotep	C R	G			

[1] See text for explanation (p. 26).

[2] D=domestic, C=commercial, R=restricted, H=home, G=greenhouse, I=interior landscape.

Biocontrols have been used extensively in outdoor situations. However, information on the life histories of scales and their predators in indoor situations is scanty (Steiner & Elliott 1983). One manager (who used to do maintenance) uses biocontrols for scales, but did not identify the agent.

Chrysopa carnea Stephens feeds on immature scales and *Cryptolaemus montrouzieri* Mulsant will also feed on scales if mealybugs are not available (Steiner & Elliott 1983). A parasitic wasp is available, *Metaphycus helvolus* (Compere) (Hymenoptera: Encyrtidae), and is particularly effective against hemispherical scale (Steiner & Elliott 1983). In a letter to the IPM Practitioner (June/July 1985) Steve

Montane of the University of California at Santa Cruz used *M. helvolus* to reduce *C. hesperidium* populations on eight 12 foot Scheffleras. He stated that the parasitism was not up to significant levels yet and asked for advice on how to improve these levels. The response, by W. Olkowski, was to: 1) increase shading and humidity, since the parasites are more active where humidity is highest; 2) control ants, since they interfere with many natural enemies; 3) use *Wheast*™ as a feeding supplement which provides a protein supplement to increase egg production; and 4) use slow-release, low nitrogen fertilizer, since scales respond to increases in available nitrogen.

For diaspids the predator *C. carnea* may provide limited control. There are many coccinellid beetle predators in nature but none are currently available commercially (Steiner & Elliott 1983). A parasite, *Aphytis melinus* DeBach (Hymenoptera: Encyrtidae, reportedly controls California red scale, oleander scale and others (Steiner & Elliott 1983).

In greenhouses chlorpyrifos, malathion, parathion (smoke), sulfotep (smoke), or Safer's® are recommended (BCMAF 1984). Enstar®, an insect growth regulator (IGR), is also recommended (Steiner & Elliott 1983) especially if biocontrol agents are also used.

Pesticide trials were conducted against *Saissetia coffeae* on *Aphelandra squarrosa* (Hamlen 1975*a*). Four foliar sprays at one month intervals of acephate, carbofuran, isazophos, dimethoate, oxamyl, oxydemetonmethyl, and phenthoate were all equally effective in reducing populations but none had been eliminated four months post initial treatment. Some of these chemicals were also applied as drenches or granules, sometimes with different results than foliar sprays of the same chemical. Aldicarb (granules), oxamyl (granules and drench), and oxydemetonmethyl (drench) did not affect populations; however, carbofuran and dimethoate drenches (3 times at 3 week intervals) and granular applications of carbofuran and thiofanox did. Hamlen believed that higher dosages could result in greater control of *Saissetia coffeae*, but did not recommend such practices due to possible phytotoxic reactions and hazards to applicators. In this trial, acephate sprays caused leaf drop, and carbofuran drenches produced interveinal necrosis of mature foliage.

Similarly IGR's (triprene, kinoprene, hydroprene, and Hoffman-La Roche Ro 20-3600) were tested against *S. coffeae* on *Aphelandra squarrosa* (Hamlen 1975*b*). There were no significant differences between them; all reduced, but did not eliminate, populations by 4 months post initial treatment.

f. <u>Thrips (Thysanoptera: Thripidae, Phlaeothripidae)</u>

There are a number of species of thrips that can attack foliage plants. The more common ones are: the banded greenhouse thrips, *Hercinothrips femoralis* (O.M. Reuter); Cuban laurel thrips, *Gynaikothrips ficorum* (Marchal); greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché); dracaena thrips, *Parthenothrips nipae* Heeger; and *Echinothrips americanus* Morgan.

In general, adults are roughly 3mm long, with 2 pairs of fringed wings. They can be yellow, tan, brown, or black depending on the species (Nelson 1981).

The eggs of *G. ficorum* are whitish, cylindrical with rounded ends, and are laid in great numbers (Brown & Eads 1979). The immature stages are yellowish white. Their life cycle lasts anywhere from 23 to 31 days, depending on the temperature.

Adults and larvae feed primarily on young tissue, by rasping the surface and sucking the exuding sap (Hamlen *et al*. 1981). Injured tissue dries out, giving a whitish, silver-flecked appearance. Injury occurs in streaks rather than in a stippled pattern. As the cells dry out the injured areas turn tan or brown (Nelson 1981, Hamlen *et al*. 1981).

Heavy infestations cause noticeable deposits of fecal material. Some typical hosts are *Aphelandra*, *Araucaria*, *Brassaia*, *Dieffenbachia*, *Philodendron*, *Sansevieria*, and *Syngonium*. Cuban laurel thrips can produce severe leaf deformation and defoliation of *Ficus retusa nitida*.

Besides damage to the plant, many species of thrips will bite people and thus create a serious problem if large populations develop (Parella 1980*b*).

Control is difficult since there is as yet no satisfactory, commercially available biocontrol agent for interior landscapes (Steiner & Elliott 1983, Parella 1980*b*), and as

Table 18. Chemicals registered, recommended, and used by respondents for control of thrips.[1]

PESTICIDE	REGI-STRATION[2]	RECOM-MENDATION[2]	EMPLOYEE	USED BY MAINTENANCE MANAGER	USED BY NON MAINTENANCE MANAGER
acephate	C				
d-trans - allethrin	D				
chlorpyrifos	C	G			
diazinon	C	H G I	1	1	1
dichlorvos	C				
lindane	C	G			
malathion	D C	H		1	
methoxychlor	D C				
nicotine	C				
oxydemeton-methyl	C				
parathion	R	G			
pyrethrins	D	H		2	
resmethrin	D				
rotenone	D	H			
soap		H I	3	3	1
sulfotep	C R				

[1] See text for explanation (p. 26).

[2] D=domestic, C=commercial, R=restricted, H=home, G=greenhouse, I=interior landscape.

they are also thigmotactic (prefering tight places), thorough coverage by pesticides is difficult (Parella 1980*b*). For species which pupate in the soil, a soil surface application of diazinon is recommended (Steiner & Elliott 1983). Frequent spot treatments of Safer's® are recommended for *Heliothrips haemorrhoidalis* since it spends its entire life in the foliage (Steiner & Elliott 1983). Other possible foliar sprays (BCMAF 1982) are pyrethrum, rotenone, malathion, and diazinon. Americans have the following registered for interior use: bendiocarb, resmethrin, insecticidal soap, and an oil spray (Parella 1980*b*).

Materials used by the employee and non-maintenance respondents are diazinon and Safer's®. Maintenance managers added malathion, pyrethrum and Raid® (=pyrethrins) to their arsenal. If the plants can be removed to the greenhouse then chlorpyrifos, diazinon, lindane, or parathion (smoke) are also available (BCMAF 1984).

Wherever the control is done, though, some species are quite mobile and hence reinfestation can be a constant problem (Parella 1980*b*). Pesticide information for thrips on interior foliage plants is summarized in table 18.

As previously mentioned, no biocontrol agents are commercially available for interior use in North America. However, there are a few in use in European greenhouses on an experimental basis (Parella 1980*b*, D. Elliott, personal communication). Two of these are species of fungi (*Cephalosporium lecanii*, *Entomophthora thripidium*) which are effective in controlling thrips populations. However, high humidity is required and thus would probably preclude their use in interiors. The use of predaceous mites (especially *Amblyseius mckenziei* Schuster and Pritchard) appears promising in Europe. "It was tried in Alberta in one location without noticeable effect on onion thrips" (Steiner & Elliott 1983, p. 23).

In greenhouse trials (Hamlen 1977*c*) permethrin, aldicarb, and acephate rapidly reduced numbers by 7 days post initial treatment (i.e. from 6/leaf to 1/leaf). A second application of oxamyl, oxydemetonmethyl also reduced populations by the next count (21 days post initial treatment). Diazinon failed to produce effective control.

Resmethrin (0.3, 0.6 g ai/ℓ) and permethrin (0.15, 0.3 g ai/ℓ) were tested for control of *Echinothrips americanus* on *Dieffenbachia maculata* (Hamlen & Henley 1980). All rates reduced populations one day post initial treatment. However, two additional treatments at 7 day intervals were necessary with resmethrin to keep numbers low. Permethrin was equal in efficacy independant of the number of times applied.

Oxydemetonmethyl, aldicarb, diazinon, dicarbasulf, methomyl, resmethrin, aldoxycarb, and acephate all were effective in reducing *Hercinothrips femoralis* populations on chrysanthemum, 3 days post treatment. Granular treatments (aldicarb, aldoxycarb, and acephate) "were effective in rapid knockdown which indicated activity as a fumigant in addition to/or rather than systemic uptake" (Oetting & Beshear 1980, p. 476).

g. <u>Whiteflies (Homoptera: Aleyrodidae)</u>

The greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), is usually not a pest of interior foliage plants. Adults are about 1mm long, have two pairs of wings covered with a white waxy material, and resemble miniature moths. They tend to aggregate on younger or newly formed foliage.

An adult female can lay up to 400 eggs (Barclay *et al.* 1984) usually in groups of 30 to 40. First instar larvae emerge after 5-10 days. There are 5 instars, the fifth being a pupal stage (Chapman 1971). The complete life cycle takes about 3 weeks at an average temperature of 21°C.

Adults and immatures feed with piercing-sucking mouthparts, although adults feed very little. The immatures produce honeydew. Seriously-affected foliage becomes chlorotic and wilted.

Chemical control of whiteflies can be difficult due to alate (winged) adults which can re-infest plants. As well, none of the registered chemicals will kill the eggs; however, pesticides, such as Morestan, will kill the eggs (D. Elliott, personal communication). Table 19 shows pesticides registered, recommended, and used by respondents. BCMAF (1982) recommends malathion, pyrethrum, rotenone, or Safer's® be applied at 3 day intervals till all whiteflies have disappeared. Diazinon should not be included in this list, since, as mentioned in the section for mealybugs, the domestic use of diazinon is for soil insects. There is a commercially registered product with diazinon (PCP #12461) which can be used for whitefly control but only on greenhouse ornamentals. Strategies employed by the employee respondents were: Safer's®, improve watering, and the use of parasites. Maintenance managers employed malathion, Raid®, and Safer's®; non-maintenance managers used Ambush® (=permethrin) and Safer's® (tables 10, 19).

Biological control has been successful in greenhouses on tomatoes, and cucumbers. The major agent used is the parasite *Encarsia formosa* Gahan

Table 19. Chemicals registered, recommended, and used by respondents for control of whiteflies.[1]

PESTICIDE	REGISTRATION[2]	RECOMMENDATION[2]	USED BY: EMPLOYEE	USED BY: MAINTENANCE MANAGER	USED BY: MAINTENANCE MANAGER
chlorpyrifos	C	G			
demeton	C R				
diazinon	C	H			
dichlorvos	C	G			
endosulfan	C	G			
kinoprene	C	G I			
lindane	C				
malathion	D C	H		1	
methoxychlor	D				
methoprene	D				
naled	C	G			
parathion	R				
permethrin	C	G			1
pyrethrins	D	H		1	
resmethrin	D				
rotenone	D	H			
soap	D C	H G I	2	3	1
sulfotep	C R				
tetramethrin	D C				

[1] See text for explanation (p. 26).

[2] D=domestic, C=commercial, R=restricted, H=home, G=greenhouse, I=interior landscape.

(Hymenoptera: Encyrtidae). However, success of biocontrol methods in interior plantings has been variable (Steiner & Elliott 1983). One non-maintenance manager has tried *E. formosa* but did not continue its use. His reasons were: "We seldom deal with an environment usually individual plants. To clients a bug is a bug harmful or beneficial" (see page 24 as well). *Encarsia* is used successfully in the West Edmonton Mall (D. Elliott, personal communication).

E. SUMMARY AND CONCLUSIONS

In this paper, I describe the range of arthropod pest problems in interior plantscapes and, with the aid of questionnaires, determine which of those pest problems are present in the interior plantscape industry of Vancouver, and how they are being approached.

A large number of pests may occur in interior landscapes. I found 40 species mentioned in the literature, but undoubtedly there are others. These numbers however, can be reduced to 7 general categories: aphids, fungus gnats, mealybugs, mites, scales, thrips, and whiteflies. As well, of the 6 insect groups, 4 belong to the order Homoptera (aphids, whiteflies, mealybugs, and scales), with the latter 2 belonging to the same superfamily, Coccoidea. Thus, though the numbers of interior landscape pests may seem high, their diversity is not as great as one might expect.

Since it was not expected that people in the interior landscape industry of Vancouver were expert entomologists, the questionnaires dealt with pest groups and not with any particular species. The questionnaires were aimed at two groups, managers and employees. This was done, in part, to help evaluate the information the 2 groups expected to provide, e.g., management of the firm; and also to detect any differences in opinions.

Differences of opinion were definitely found; though the groups tended to agree on major issues. 'Poor light' was perceived by all to be the major cause of plant loss in interior plantscapes. 'Insects', 'disease', and 'watering techniques' were next in importance, though the degree of importance varied according to the respondent group.

'Mites' were perceived by all to be the most frequent pest and the most difficult to control. There were differences in opinion as to which pests were the next most frequent in occurrence. However, both employees and maintenance managers perceived scales as the next most difficult pest to control.

Results from the questionnaire showed that Safer's® Insecticidal Soap was the most widely used pesticide for control of pests on interior foliage plants. It is used for such obvious reasons as: wide spectrum activity, low phytotoxicity and, perhaps most importantly, its name. As soap is common in general household use, spraying office plants with soap avoids the alarming 'pesticide' label. I fear though, that as effective as Safer's is, it may be overused, perhaps to the exclusion of more effective methods.

Diazinon is the second most frequently chosen pesticide. However, before using diazinon, alternative, non-chemical means were more frequently chosen by employees. As well, more employees have a pesticide applicators licence than do managers. Perhaps the process of obtaining the licence discourages its use by providing information on alternative control methods.

The number of different pesticides used is generally only half of the number registered for use on interior foliage plants. Possible reasons for this are:

a. registration information that is not clear as to what is legal to use in interior plantscapes, or
b. lack of knowledge of other products, or
c. other products were tried but found ineffective, or
d. other products were tried but found to be phytotoxic, or
e. they were found to be unsuitable (i.e. smell, impractical packaging; e.g., a small pump spray used to control pests on a large *Ficus* tree).

Since the number of pesticides registered for use in interior plantscapes is limited, and the public, in general, is adverse to the use of pesticides, one would expect a higher usage of biocontrol agents. Of the respondents, 25% have tried biocontrols but only 16% continue to use them.

There are advantages and disadvantages to the use of biocontrols in interior landscapes (Malmon 1985). The advantages are:

a. safety,
b. only method possible (due to either pesticide resistance, or lack of registered products),
c. species specific,
d. cost (lower in some situations), and

e. biocontrols enhance public relations.

The disadvantages are:

a. availability problems,

b. they do not work as quickly as chemicals,

c. environmental problems,

d. restricts the use of chemicals,

e. complexity (if there is more than one pest),

f. time and expense (personnel must be trained in their use).

The above points are generally self-explanatory, however some require clarification.

Availability is somewhat of a 'Catch-22' situation. There is not much of a supply since the demand is not great; the demand is not great because there is not much of a supply. Producing small batches, for the initial demands, is not profitable for the supplier (D. Elliott, personal communication).

Biocontrol agents have not been found for every pest species yet. *Phytoseiulus persimilis* and *Encarsia formosa* are under commercial production at Applied Bionomics, Sidney, B.C., and are effective for control of *Tetranychus urticae* and *Trialeurodes vaporariorum* respectively. Other agents are also available but originate from the USA. The problem arises because biocontrol agents are perishable; they cannot be stock-piled when availability is high. Yet, they must be obtained and introduced as soon as possible after the pest problem is identified.

Biocontrol agents do not reduce pest populations as fast as effective pesticides and thus the pest problem must be identified when the populations are still low. An alternative to identifying problems when they arise is to use the 'dribble' method whereby biocontrol agents are introduced in small numbers early in the season before any pests are noticed. Periodic re-introductions are made throughout the season to ensure that there are always some beneficials present. This method is used at the West Edmonton Mall and is apparently quite effective with *E. formosa* and *P. persimilis* (D. Elliott, personal communication).

Environmental problems can be a major drawback to effective use of biocontrols. For example, *P. persimilis* "doesn't work well in high temperatures or bright light. It also needs moderate (40–60%) humidity, which can be a problem in air-conditioned interiors." (Malmon 1985, p. 29).

The use of biocontrols in interior landscapes is still too recent to permit prediction of success with every application (D. Elliott, personal communication) and personnel have yet to be trained in the use of biocontrol agents. It is for these reasons that Don Elliott of Applied Bio-nomics is not further advertising his products for use in interior plantscapes, though he is willing to help when approached by interior landscape firms. As there is not enough information to date, he feels the negligent use of biocontrols could give them a bad name, and hamper the expansion of their use.

In general, when considering solutions to pest problems, four main areas come to mind:

1. pesticides,
2. biological controls,
3. use of resistant plant and biocontrol species, and
4. habitat manipulation and plant health.

The assumption behind the last point is: the healthier a plant is, the less susceptible it will be to pests. The best approach to this type of solution is to include an interior plantscaper in the design process of a new building. In this way, the areas to be used for plantscapes will have the necessary requirements for plant health. This was not always the case, but the trend is changing (Gaines 1977). The next best approach would be a better selection of plants which will survive in the available conditions and the provision of proper care (especially watering techniques). This, I feel, will promote better plant health and reduce the number of pest problems, and therefore, decreasing the need to replace plants.

The use of pest-resistant plants should be encouraged and is a large area for further research. There are two recent introductions to the market which should help some situations. *Brassaia actinophylla* 'Amate' is marketed as mite resistant and *Ficus benjamina* 'Green Gem' as thrips resistant. The industry, though, should not rely too heavily on this method, since it will not be able to produce a sufficient variety of plants resistant to all pests.

The two points mentioned above are preventative in nature. The majority of pest problems, however, require an immediate approach and the use of pesticides and biocontrols fall into this category.

The advantages and disadvantages of biocontrols have already been mentioned. What needs to be done in this area is more research. More information is needed on biocontrols currently in use or under testing in order to better predict which environmental conditions are necessary for success. To widen the choices of pest management strategies pesticide-resistant strains of biocontrol agents need to be developed which have a broader range of resistance. With biocontrol agents in use for some pests, this would allow the use of pesticides to control other pest problems for which there are no biocontrol agents available yet.

Pesticides are usually the last or only option. There are many areas for improvement, some of which have been listed previously (page 58).

Labelling information should be made clearer. This is currently under review for products registered for use in greenhouses. Domestic products are usually for home and garden use. They can also be used in offices and the label should state this.

There should be an easy way of obtaining a current list of products available for use in interior landscapes. A database is being developed by the Pesticides Directorate, Agriculture Canada; however, there is no particular code for interior plantscapes that would allow an easy search.

Even with more information regarding the available products, many may be phytotoxic or ineffective. Since the interior landscape industry forms a very small portion of the pesticide market, research by the large pesticide manufacturers to produce new products seems unlikely. Therefore, more use should be made of the minor use registration program of Agriculture Canada. Amendments to labels of currently registered products would give more choices than are currently available.

The interior landscape industry has only really developed in the past 10–15 years. Interior landscapes are probably still considered a luxury (although a rather necessary luxury, I feel) and the industry is most likely to be greatly affected by general economic trends. During difficult economic times, the interior landscape industry will undoubtably feel the effects of cutbacks.

There is still much to be done in the areas of pest control, as well as plant production practices, development of new plant varieties, etc. With the growth of the industry, this knowledge will increase and hopefully be easily accessible to people in the industry. Pest managers can be involved in quite a number of areas, such as: finding new pesticides, new uses of current pesticides, or new biocontrol agents; developing resistant strains of current biocontrol agents; and providing consultant services to interior landscaping firms.

Contemporary architecture has evolved in such a way that plantscapes have become an integral part of interior design. But plants are more than fashionable furnishings, they are a functional part of the environment, providing privacy, improving acoustics and directing traffic patterns. Proper care and maintenance of this multi-faceted asset is essential.

LITERATURE CITED

Allen, W.W., Morishita, F.S., Bowen, W.R. & Koehler, C.S. 1980. Insect and Mite Control Guide for California Commercial Floriculture Crops. Berkeley, CA: University of California. Cooperative Extension Leaflet #2181.

Agriculture Canada. 1984. *Registration Guidelines.* Ottawa, Ontario: Agriculture Canada. Plant Health & Plant Products Directorate. Pesticides Division.

Barclay, L.W. & Koehler, C.S. 1980. Mealybugs on House Plants and in the Home Landscape. Berkeley, CA: University of California. Cooperative Extension Leaflet #21197.

Barclay, L.W., Koehler, C.S. & Bowen, W.R. 1984. Whiteflies on Outdoor and Indoor Plants. Berkeley, CA: University of California. Cooperative Extension Leaflet #21267.

Barmby, B.A. & Pate, A.J. 1979. Foliage plant problems diagnosed by commercial grower's clinic - A three year summary. Proc. Fla. State hort. Soc. **92**:334-336.

____________ 1981. Commercial foliage plant grower's clinic - Trends reported for a five-year period. Proc. Fla. State hort. Soc. **94**:102-103,

Barmby, B.A., Brown, R.L. & Henley, R.W. 1977. Problems identified in an extension-operated clinic for commercial foliage plant producers. Proc. Fla. State hort. Soc. **90**:299-301.

British Columbia Ministry of Agriculture and Food (BCMAF). 1982. *Pest Control in the Home and Garden.* Victoria, BC: Ministry of Agriculture and Food.

____________ 1984. *Greenhouse Ornamental and Bedding Plant Pest Control Guide - 1984.* Victoria, BC: Ministry of Agriculture and Food.

Brown, L.R. & Eads, C.O. 1979. Cuban Laurel Thrips. Berkeley, CA: University of California. Cooperative Extension Leaflet #2536.

Canada. Department of Agriculture. 1978. *(Pest Control Products Act) Pest Control Products Regulations.* Ottawa: Queen's Printer.

Cathey, H.M., Campbell, L.E. & Thimijan, R.W. 1978. Comparative development of 11 plants grown under various fluorescent lamps and different durations of irradiation with and without additional incandescent lighting. J. amer. Soc. hort. Sci. **103**(6):781-791.

Chandler, L.D. 1980. Greenhouse insecticide evaluations for suppression of citrus mealybug on ornamental foliage plants. College Station, TX: Texas Agricultural Experiment Station. Progress Report #PR-3685.

Chapman, R.F. 1971. *The Insects: Structure & Function.* London, UK: The English Universities Press.

Chase, A.R. 1985. Diseases of foliage plants — revised list for 1985. Foliage Digest **8**(6):3-8.

Conklin, E. 1972. Man and plants - a primal association. American Nurseryman **136**(9):42,46-49.

Conover, C.A. 1969. Foliage stock plant production. Florida Foliage Grower **6**(5):1-8.

____________ 1974. Production and research on tropical plants in the Americas. Proc. XIX International Horticultural Congress **4**:169-178

Conover, C.A. & McConnell, D.B. 1981. Utilization of foliage plants. **In** J.N. Joiner, ed. *Foliage Plant Production*. pp. 519-543. Englewood Cliffs, NJ: Prentice-Hall.

Conover, C.A. & Poole, R.T. 1981. Environmental factors. **In** J.N. Joiner, ed. *Foliage Plant Production*. pp. 269-283. Englewood Cliffs, NJ: Prentice-Hall.

Conover, C.A., Poole, R.T., Knaus, J.F., Hamlen, R.A. & Henley, R.W. 1973. Florida's changing foliage industry. Hortscience **8**:462-464.

Deckle, G.W. 1976. Florida Armoured Scale Insects. **In** *Arthropods of Florida and Neighbouring Land Areas*. vol. 3. Gainesville, FL: Dept. of Agriculture & Consumer Services. Division of Plant Industry.

Denmark, H.A. & Nickerson, E. 1981. A Tarsonemid mite, *Steneotarsonemus furcatus* de Leon, a serious pest on *Maranta* sp. and *Calathea* sp. (Acarina: Tarsonemidae). Proc. Fla. State hort. Soc. **94**:70-72.

Furuta, T. 1983. *Interior Landscaping*. Reston, VA: Reston Publishing Co. Inc.

Gaines, R.L. 1977. *Interior Plantscaping*. New York, NY: Architectural Record.

Hamlen, R.A. 1974. The broad mite: a new and important pest of greenhouse grown Aphelandra. J. econ. Ent. **67**:791-792.

____________ 1975*a*. Hemispherical scale control on greenhouse grown Aphelandra. Florida Entomologist **58**(3):187-192.

____________ 1975*b*. Insect growth regulator control of longtailed mealybug, hemispherical scale and *Phenacoccus solani* on ornamental foliage plants. J. econ. Ent. **68**:223-226.

____________ 1976. The efficacy and potential phytotoxicity of aerosols for insect and mite control on tropical foliage plants. Proc. Fla. State hort. Soc. **89**:332-334.

____________ 1977*a*. Activity of methoprene, cycloprene miticide, and resmethrin formulation against pests of ornamentals. Florida Entomologist **60**(3):166.

____________ 1977*b*. Insecticide and insect growth regulator control of green peach aphid, banded greenhouse thrips and a foliar mealybug on Aphelandra. Proc. Fla. State hort. Soc. **90**:321-323.

____________ 1977*c*. Insecticide and insect growth regulator control of green peach aphid, banded greenhouse thrips, and a foliar mealybug on Aphelandra. Proc. Fla. State hort. Soc. **90**:321-323.

____________ 1978. Biological control of spider mites on greenhouse ornamentals using predaceous mites. Proc. Fla. State hort. Soc. **91**:247-249.

Hamlen, R.A., Dickson, D.W., Short, D.E. & Stokes, D.E. 1981. Insects, mites, nematodes and other pests. **In** J.N. Joiner, ed. *Foliage Plant Production*. pp. 428-479. Englewood Cliffs, NJ: Prentice-Hall.

Hamlen, R.A. & Henley, R.W. 1977. Home and garden aerosols for insects and mite control on foliage plants indoors. Florida Foliage Grower **14**(5):1-5.

____________ 1979. Pest control and phytotoxicity on indoor ornamental plants with dichlorvos fumigation. J. am. Soc. hort. Sci. **104**(1):136-138.

____________ 1980. Synthetic pyrethroid insecticides, resmethrin and permethrin, for tropical foliage plant protection. Hortscience **15**(6):820-821.

Hamlen, R.A. & Lindquist, R.K. 1981. Comparison of two *Phytoseiulus* species as predators of twospotted spider mites on greenhouse ornamentals. Env. Ent. **10**:524-527.

Hamlen, R.A. & Mead, F.W. 1979. Fungus gnat larval control in greenhouse plant production. J. econ. Ent. **72**:269-271.

Hamlen, R.A. & Poole, R.T. 1980. Effects of a predaceous mite on spider mite populations of *Dieffenbachia* under greenhouse and interior environments. Hortscience **15**(5):611-612.

Hamlen, R.A., Short, D.E. & Henley, R.W. 1978. Detection and identification of insects and related pests of the commercial foliage industry. Circular 432, Florida Cooperative Extension Service. Institute of Foood & Agricultural Sciences, University of Florida. Gainesville, FL. 23pp.

Hamlen, R.A. & Wettstein, M.V. 1978. Soil insect and nematode pests of tropical foliage plants. Florists' Review **162**(4195):22-23, 73-75.

Hassell, K.A. 1982. *The Chemistry of Pesticides: their metabolism, mode of action and uses in crop protection*. Basel: Verlag Chemie.

Henley, R.W. & Poole, R.T. 1981. Water and foliage plants. In J.N. Joiner, ed. *Foliage Plant Production*. pp. 203-228. Englewood Cliffs, NJ: Prentice-Hall.

Highland, H.A. 1956. The biology of *Ferrisiana virgata*, a pest of azaleas. J. econ. Ent. **49**(2):276-277.

Hill, D.S. 1983. *Agricultural pests of the tropics and their control*. Cambridge, UK: Cambridge University Press.

Hungerford, H.B. 1916. Sciara maggots injurious to potted plants. J. econ. Ent. **9**:538-549.

Jeppson, L.R., Keifer, H.H. & Baker, E.W. 1975. *Mites injurious to economic plants*. Berkeley, CA: University of California Press.

Icon Micrographics. 1984. *Pest Control Products Registered in Canada*. Ottawa, Ontario: Icon Micrographics Ltd. (microfiche).

Lindquist, R.K. 1981*a*. Introduction of predators for insect and mite control on commercial interior plantings. Ohio Florists' Association Bulletin #622:5,8

____________ 1981*b*. Controlling the citrus mealybug on greenhouse foliage plants. Ohio Florists' Association Bulletin #622:6,8

____________ 1981*c*. Foliage plants, *T. urticae* control, Wooster, Ohio, 1978. Insecticide and Acaricide Tests **5**:175-176.

MacKenzie, H.L. 1967. *Mealybugs of California.* Berkeley, CA: University of California Press.

Malmon, J.G. 1985. Biological warfare. Interior Landscape Industry **2**(6):22–32.

Manaker, G.H. 1981. *Interior Plantscapes: Installation, Maintenance and Management.* Englewood Cliffs, NJ: Prentice-Hall Inc.

Manglitz, G.R. & Cory, E.N. 1953. Biology and control of *Brevipalpus australis.* J. econ. Ent. **46**:116–119.

Mastick, D.F. 1977. Plant maintenance is the key to successful interior landscaping. Florists' Review **161**(4174):30, 74–77.

McDuffie, R.F. 1984. The design process. Interior Landscape Industry **1**(9):36–39.

Miller, D.R. & Kosztarab, M. 1979. Recent advances in the study of scale insects. Ann. Rev. Ent. **24**:1–27.

Morishita, F.S. 1954. Biology and control of *Brevipalpus inornatus* (Banks). J. econ. Ent. **47**:449–456.

Nelson, P.V. 1981. *Greenhouse operation and management.* Reston, VA: Reston Publishing Co. Inc.

Oetting, R.D. 1982. Systemic activity of acephate, butoxycarboxim and butocarboxim for control of *Myzus persicae* on ornamentals. J. Ga. ent. Soc. **17**(4):433–438.

Oetting, R.A. & Beshear, R.J. 1980. Host selection and control of the banded greenhouse thrips on ornamentals. J. Ga. ent. Soc. **15**(4):475–479.

Oetting, R.A. & Morishita, F.S. 1978. Twospotted spider mite control on greenhouse ornamentals, California, 1977. Insecticide and Acaracide Tests **3**:157–158.

____________ 1979. Greenhouse ornamentals, two-spotted spider mite control, California, 1978. Insecticide and Acaricide Tests **4**:186–187.

Oppenheim, A.N. 1966. *Questionnaire Design and Attitude Measurement.* New York, NY: Basic Books, Inc.

Osborne, L.S. 1982. Is soap a viable method for controlling *Tetranychus urticae* on plants in the interior environments. Proc. Fla. State hort. Soc. **95**:149–151.

____________ 1984. Soap spray: An alternative to a conventional acaricide for controlling the twospotted spider mite (Acari: Tetranychidae) in the greenhouse. J. econ. ent. **77**(3):734–737.

Parella, M.P. 1980*a*. Pests of interior plants – Mealybugs. **In** J. Dockery, ed. *Manual of Practice.* pp. H81a–H81g. Reston, VA: Interior Plantscape Association.

____________ 1980*b*. Arthropod pests of interior plants II. Thrips. **In** J. Dockery, ed. *Manual of Practice.* pp. H81h–H81l. Reston, VA: Interior Plantscape Association.

Pemberton, L. 1980. The history and origins of interior plants. **In** S. Scrivens. *Interior Planting in Large Buildings.* pp. 7–13. London, UK: Architectural Press.

Poe, S.L., Short, D.S. & Dekle, G.W. 1973. Control of *Rhizoecus americanus* (Homoptera: Pseudococcidae) on ornamental plants. J. Ga. ent. Soc. **8**(1):20–26.

Poole, R.T. & Conover, C.A. 1982. Influence of cultural conditions on simulated shipping of *Ficus benjamina* L. Proc. Fla. State Hort. Soc. **95**:172–173.

Sabelis, M.W. 1981. Biological control of two-spotted spidermites using phytoseiid predators. Part I: Modelling the predator-prey interaction at the individual level. Wageningen, NL: Agricultural University.; Agricultural Research Reports (Versl. landbouw. Onderz.) #910.

Scott, J.A. ed. 1984*a*. Compendium of pest control products registered in Canada. Arthropod and Mollusc controls. Volume code: IN. Ottawa, Ontario: Agriculture Canada. Plant Products & Quarantine Directorate. Pesticides Division. Publication 1654 IN/84.

__________ 1984*b*. Compendium of pest control products registered in Canada. Registered pest control products. Volume code: RP. Ottawa, Ontario: Agriculture Canada. Plant products & Quarantine Directorate. Pesticides Division. Publication 1654 RP/84.

Short, D.E., Osborne, L.S., Mizell, R.F. & Henley, R.W. 1984. 1984 Insect and related arthropod management guide for commercial and woody ornamental plants in Florida. Apopka, FL: Agriculture Research Centre, Entomology Extension Report #52.

Smith, C.N. & Scarborough, E.F. 1981. Status and development of foliage plant industries. **In** J.N. Joiner, ed. *Foliage Plant Production*. pp. 1–39. Englewood Cliffs, NJ: Prentice-Hall.

Steffan, W.A. 1966. *A generic revision of the family Sciaridae (Diptera) of America north of Mexico.* Berkeley, CA: University of California Press.

Steiner, M.Y. & Elliott, D.P. 1983. *Biological Pest Management for Interior Plantscapes.* Vegreville, AB: Alberta Environmental Research Centre. Publication #AECV83-E1.

Tonks, N.V., Arrand, J.C., Ormrod, D.J., Mauza, B.E. & Senn, N.L. 1982. *Pest Problems in Small Greenhouses and Indoor Plantings.* Victoria, BC: Ministry of Agriculture and Food.

Topping, R. 1980. Interior design perspective. **In** J. Dockery, ed. *Manual of Practice*. p. D-5. Reston, VA: Interior Plantscape Association.

United States Crop Reporting Board. 1982. *Floriculture Crops. Production area and sales, 1980 & 1981. Intentions for 1982.* Washington, DC: United States Department of Agriculture. Publication #SpCr6-1(82).

Vulić, M. & Braunling, H. 1974. Über ein neues bekampfungsverfahren von blattlausen und spinnmilben im zierpflanzenbau mit insectizid-stabchen. Mededelingen Rijksfaculteit Landbouwwetenschappen Ghent **2**(1):847–856.

Woodham, T. & Gainey, R. 1980*a*. Abstract or pure design. **In** J. Dockery, ed. *Manual of Practice*. pp. D3–D4. Reston, VA: Interior Plantscape Association.

__________ 1980*b*. Design qualities of plants. **In** J. Dockery, ed. *Manual of Practice*. pp. D11–D17. Reston, VA: Interior Plantscape Association.

Worthing, C.R. 1979. Butoxycarboxim. In: *The Pesticide Manual: a world compendium.* p. 67. Croydon, UK: British Crop Protection Council.

APPENDIX A. - SAMPLE COVER LETTER

SAMPLE COVER LETTER

Terra Plants & Flowers
6551 #3 Road
Richmond Square
Richmond, BC
V6Y 2B6

March 2, 1986

Dear Sir/Madam:

Enclosed are the questionnaires I mentioned in our telephone conversation. The questionnaire is part of my Master's thesis and is basically a 'fact-finding mission'. I hope to find out how you, as part of the Interior Landscape industry in Vancouver, deal with your pest problems, if any. I used to do plant maintenance in Ottawa, so I am very curious to see if things are any different here on the West Coast.

I hope you will be able to take the time to answer the questionnaire. Please feel free to elaborate if any question does not allow you to give a full response. An envelope is provided so you can return the questionnaire by mail and thus all responses will be anonymous.

Results of the questionnaire will be available if you so desire. I hope the information will be as useful to you as it will be to me.

Please feel free to contact me if you have any problems (SFU: 291-4697).

Sincerely,

Keith Jongejan

APPENDIX B. - QUESTIONNAIRE FOR INTERIOR LANDSCAPE MANAGERS

Instructions:

Please fill in the blank, check the box beside your answer or fill it in with a number, whichever is appropriate.

1. How long have you been employed in the interior landscape industry?

   |___| years |___| months

2. How long has your department/firm been in operation?

   |___| years |___| months

3. How many people are currently employed by you?

   |___| full time

   |___| part time

4. How do they work?

   |_| alone

   |_| in pairs

   |_| other? ____________________

5. Do you have different routes?

   |_| yes

   |_| no

   If yes, are people rotated from route to route?

   |_| yes

   |_| no

6. Do you have a pesticide applicators licence?

|_| yes

|_| no

If yes, how long have you had it?

|____| years |____| months

7. How many of your employees have a pesticide applicator licence?

|____|

8. Do you have problems getting quality plant material?

|_| yes

|_| no

9. Where do you get your plant material from? If more than one can you give approximate percentages?

|____| British Columbia

|____| California

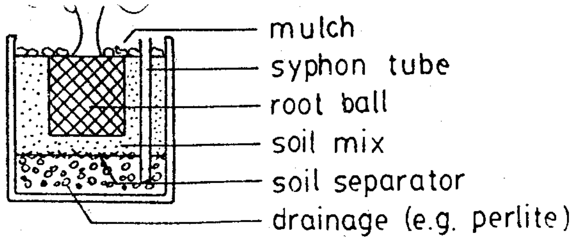
|____| Florida

|____| Texas

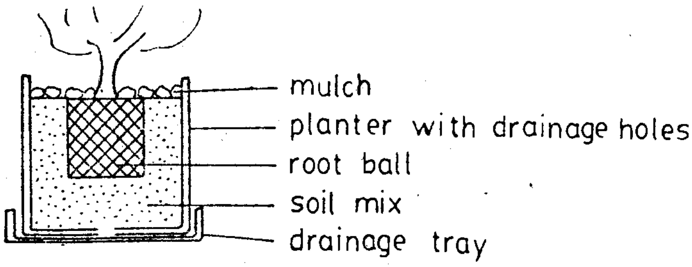
|____| other ______________________________

10. Please indicate which diagram most closely describes the potting method you use. Stroke out any label in the diagram if that part is not used. If you use more than one method, approximate the percentages of each type used.

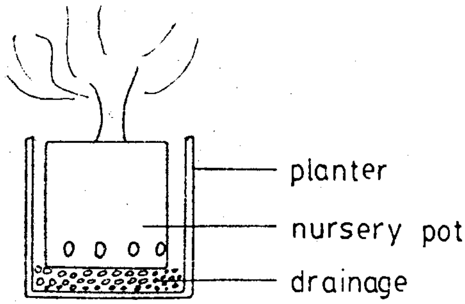
a. [ ]



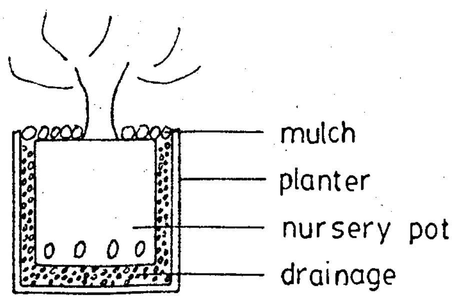
b. [ ]



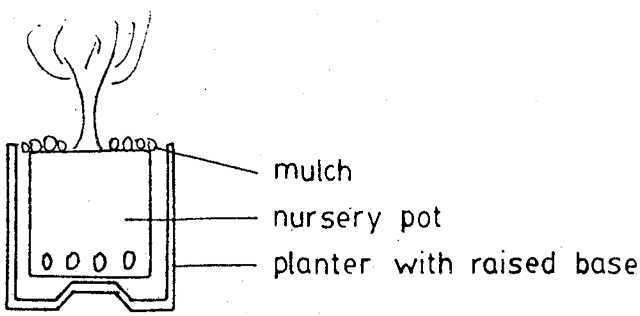
c. [ ]



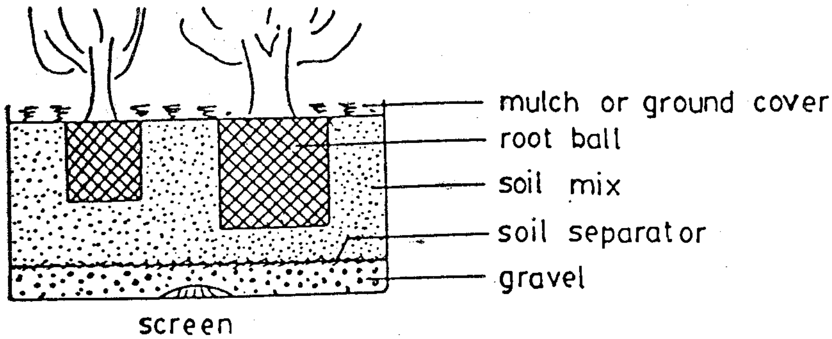
d. [ ]



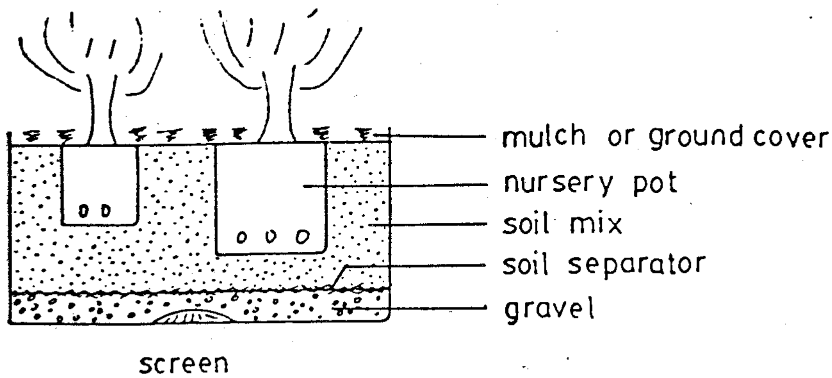
e. [ ]



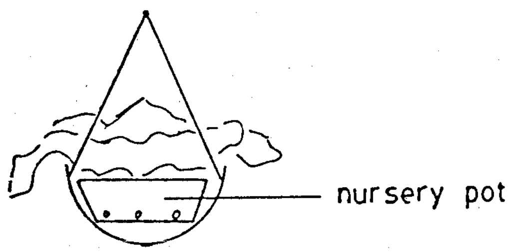
f. [ ]


mulch or ground cover
root ball
soil mix
soil separator
gravel
screen

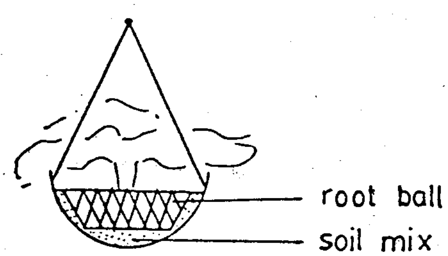
g. [ ]


mulch or ground cover
nursery pot
soil mix
soil separator
gravel
screen

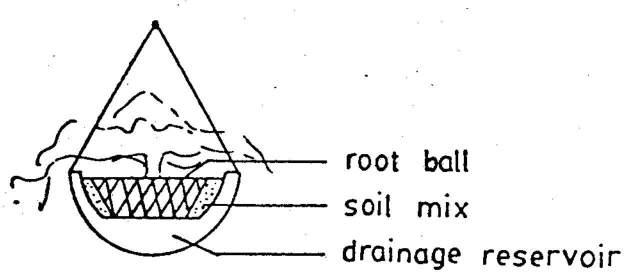
h. [ ]


nursery pot

i. [ ]


root ball
soil mix

j. [ ]


root ball
soil mix
drainage reservoir

11. How would you rank the following expenses in your operation? (1=highest, 2=next highest, etc.)

|___| chemicals

|___| labour

|___| plant replacement

|___| transport

|___| other? ____________________

|___| ____________________

|___| ____________________

12. Overall, what do you consider to be the top five general causes of plant loss in your contracts? (i.e. insects, disease, poor light, temperature too low, etc.) Please list from <u>most</u> important (1) to <u>least</u> important (5).

1) ________________________

2) ________________________

3) ________________________

4) ________________________

5) ________________________

13. Do you feel that the pest control methods available to you are adequate?

|_| yes

|_| no

14. Have you ever used predators or parasites?

|_| yes   If yes, which ones?

|_| no   If not skip to question 17

____

____

____

15. Do you continue to use predators or parasites?

|_| yes

|_| no

If not, which ones are no longer used and why not?

1. ____________________ : ____________________

____

____

2. ____________________ : ____________________

____

____

3. ____________________ : ____________________

____

____

16. Do you favour predators or parasites over pesticides?

|_| yes

|_| no

Any reasons?

___

___

___

17. What are your sources of information on new pest problems or new ways to handle old pest problems?

___

___

___

18. Have you taken any courses in plant maintenance (if so, please identify)?

|_| yes ___

|_| no

19. Do you do any plant maintenance yourself?

|_| yes If yes, please continue.

|_| no If not, skip to question 21

20. How often do you visit each contract?

|_| twice a week

|_| once a week

|_| once every 2 weeks

|_| once a month

|_| other? ___

21. Out of all your pest problems over the past year what percentage did the following pests form?

	percentage of all pest problems										
	0	1 - 9	10 - 19	20 - 29	30 - 39	40 - 49	50 - 59	60 - 69	70 - 79	80 - 89	90 - 100
aphid											
fungus gnats											
mealybug											
mites											
powdery mildew											
root rot											
scales											
stem rot											
thrips											
whitefly											
others?											

22. Referring to the question above (#21) was this always the case? (e.g. if mites were encountered 80-100% of the time, were they always this frequent?)

|_| yes

|_| no

If not;

a. Which pests are now under better control? Why?

____

____

____

b. Which pests were under better control in the past and now are not? Why?

____

____

____

23. Are there any particular plants that are more frequently attacked by a certain pest or disease? Please list the plant(s) and the pest(s) and/or disease(s).

	PLANT	PEST/DISEASE
1.	____________________	____________________
2.	____________________	____________________
3.	____________________	____________________
4.	____________________	____________________
5.	____________________	____________________

24. How do you control each of the following? If control depends on the type of plant, please identify the plant and the associated control method. (For example, perhaps small plants you might replace, larger ones you might spray with ??)

a. aphids: ____________________

____

b. fungus gnats: ____________________

____

c. mealybugs: ____________________

____

d. mites: ____________________

____

e. powdery mildew: ____________________

____

f. root rot: ____________________

____

g. scales: ____________________

____

h. stem rot: ____________________

____

i. thrips: ____________________

____

j. whiteflies: ____________________

____

k. others? ____________________ : ____________________

____

l. ____________________ : ____________________

____

m. ____________________ : ____________________

____

25. Which three of the above pests do you find most difficult to control? Why?

1. ____________________ : ____________________

____

____

2. ____________________ : ____________________

____

____

3. ____________________ : ____________________

____

____

26. Are there any plants that you have stopped using because of their susceptibility to pest/disease problems? If yes, what are the plants and their pest(s)/disease(s)?

	PLANT	PEST/DISEASE
1.	____________________	____________________
2.	____________________	____________________
3.	____________________	____________________

27. Are there any plants that you wish you could stop using because of pests or diseases? If yes, what is/are the plant(s) and the reasons?

1. ______________________ : ______________________

____

____

2. ______________________ : ______________________

____

____

3. ______________________ : ______________________

____

____

APPENDIX C. - QUESTIONNAIRE FOR INTERIOR LANDSCAPE PERSONNEL

Intructions:

Please fill in the blank, check the box beside your answer or fill it in with a number, whichever is appropriate.

1. How long have you been employed in the interior landscape industry?

   [ ] years [ ] months

2. Do you have a pesticide applicators licence?

   [ ] yes

   [ ] no

   If yes, how long have you had it?

   [ ] years [ ] months

3. Have you taken any courses in plant maintenance (if so, please identify)?

   [ ] yes ______________________________

   [ ] no

4. Do you work full time or part time?

   [ ] full time

   [ ] part time

5. How do you work?

   [ ] alone?

   [ ] in pairs?

   [ ] other? ______________________________

6. How often do you visit contracts?

[_] twice a week

[_] once a week

[_] once every 2 weeks

[_] once a month

[_] other? ______________________

7. How do you get from contract to contract?

[_] car

[_] foot

[_] other? ______________________

8. Overall, what do you consider to be the top five general causes of plant loss in your contracts? (i.e. insects, disease, poor light, temperature too low, etc.) Please list from <u>most</u> important (1) to <u>least</u> important (5).

1) ______________________________

2) ______________________________

3) ______________________________

4) ______________________________

5) ______________________________

9. Out of <u>all</u> your pest problems over the past year what percentage did the following pests form?

	percentage of all pest problems										
	0	1 – 9	10 – 19	20 – 29	30 – 39	40 – 49	50 – 59	60 – 69	70 – 79	80 – 89	90 – 100
aphid											
fungus gnats											
mealybug											
mites											
powdery mildew											
root rot											
scales											
stem rot											
thrips											
whitefly											
others?											

10. Referring to the question above (#9) was this always the case? (e.g. if mites were encountered 80-100% of the time, were they always this frequent?)

|_| yes

|_| no

If not;

a. Which pests are now under better control? Why?

____

____

____

b. Which pests were under better control in the past and now are not? Why?

____

____

____

11. Are there any particular plants that are more frequently attacked by a certain pest or disease? Please list the plant(s) and the pest(s) and/or disease(s).

	PLANT	PEST/DISEASE
1.	____________	____________
2.	____________	____________
3.	____________	____________
4.	____________	____________
5.	____________	____________

12. How do you control each of the following? If control depends on the type of plant, please identify the plant and the associated control method. (For example, perhaps small plants you might replace, larger ones you might spray with ??)

a. aphids: ______________________________

____

b. fungus gnats: ______________________________

____

c. mealybugs: ______________________________

____

d. mites: ______________________________

____

e. powdery mildew: ______________________________

____

f. root rot: ______________________________

____

g. scales: ______________________________

____

h. stem rot: ______________________________

____

i. thrips: ______________________________

____

j. whiteflies: ______________________________

____

k. others? ______________________ : ______________________

____

l. ______________________ : ______________________

____

m. ______________________ : ______________________

____

13. Which three of the above pests do you find most difficult to control? Why?

1. ______________________ : ______________________

____

____

2. ______________________ : ______________________

____

____

3. ______________________ : ______________________

____

____

14. What are your sources of information on new pest problems or new ways to handle old pest problems?

____

____

____

15. Do you feel that the pest control methods available to you are adequate?

|_| yes

|_| no

16. Have you ever used predators or parasites?

|_| yes If yes, which ones?

|_| no If not skip to question 19

____

____

____

17. Do you continue to use predators or parasites?

|_| yes

|_| no

If not, which ones are no longer used and why not?

1. ____________________ : ____________________

____

____

2. ____________________ : ____________________

____

____

18. Do you favour the use of predators or parasites over pesticides?

|_| yes

|_| no

Any reasons?

____

____

____

19. Are there any plants that you wish you could stop using because of their susceptibility to pests or disease? If yes, what are the plants and the reasons for not recommending them for indoor use?

1. ______________________ : ______________________________

____

____

2. ______________________ : ______________________________

____

____

3. ______________________ : ______________________________

____

____

APPENDIX D. - COMMON AND BOTANICAL NAMES OF PLANTS MENTIONED IN THE TEXT.

Aglaonema modestum Schott ex Engl.	Chinese evergreen
Aphelandra squarrosa Nees	zebra plant
Araucaria heterophylla (Salisb.) Franco.	Norfolk Island Pine
Brassaia actinophylla Endl.	schefflera
Chamaedorea elegans Mart.	parlour palm
Chamaedorea erumpens H.E. Moore	bamboo palm
Chrysalidocarpus lutescens Wendl.	Areca or Madagascar palm
Cissus antarctica Vent	kangaroo vine
Cissus rhombifolia Vahl	grape ivy
Codiaeum variegatum pictum Blume	croton
Dieffenbachia sp.	dumbcane or dieffenbachia
Dizygotheca elegantissima Vig. & Guill.	false aralia
Dracaena deremensis Engler 'Janet Craig'	Janet Craig dracaena
Dracaena marginata Lam.	dragon tree
Dracaena sanderana hort. Sander ex M.T. Mast	Sander's dracaena
Fatsia japonica (Thunb.) Decne. & Planch.	Japanese aralia
Ficus benjamina L.	weeping fig
Ficus retusa nitida Thunb.	Indian laurel
Gynura aurantiaca (Blume) DC.	velvet plant
Hedera helix L.	English ivy
Hibiscus rosa-sinensis L.	hibiscus
Hoya carnosa (L.f.) R. Br.	wax plant
Philodendron cordatum (Vell.) Kunth.	heart-leaf philodendron
Phoenix roebelenii O'Brien	dwarf date palm
Sansevieria trifasciata Prain	snake plant
Schefflera arboricola Hayata ex Kanehira	Hawaiian schefflera
Spathiphyllum spp.	spathiphyllum
Syngonium podophyllum Schott	nephthytis
Tradescantia fluminensis Vell	wandering jew

APPENDIX E. - LIST OF BIOCONTROL AGENTS MENTIONED IN THE TEXT

ACARI: PHYTOSEIIDAE

Amblyseius californicus (McGregor)	mite predator
Amblyseius mckenziei Schuster and Pritchard	mite predator
Typhlodromus (=Metaseiulus) occidentalis (Nesbitt)	mite predator
Phytoseiulus macropilis (Banks)	mite predator
Phytoseiulus persimilis Athias-Henriot	mite predator

COLEOPTERA: COCCINELLIDAE

Cryptolaemus montrouzieri Mulsant	mealybug destroyer

HYMENOPTERA: ENCYRTIDAE

Aphytis melinus DeBach	scale parasite
Encarsia formosa Gahan	greenhouse whitefly parasite
Metaphycus helvolus (Compere)	scale parasite

NEUROPTERA: CHRYSOPIDAE

Chrysopa carnea Stephens	common green lacewing