ANALYSIS OF SPECIALIZED PESTICIDE PROBLEMS

INVERTEBRATE CONTROL AGENTS-EFFICACY TEST METHODS

VOLUME X

TURFS, ORNAMENTALS, FOREST LANDS

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REPORT TO THE

ENVIRONMENTAL PROTECTION AGENCY

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VOLUME X (VOL VI REVISED)

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Report To The
Environmental Protection Agency

By The

American Institute of Biological Sciences
Arlington, Virginia 22209

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TURF, ORNAMENTALS, AND FOREST LANDS*

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INTRODUCTION

Test methods, protocols and procedures for evaluating the effectiveness of invertebrate chemical control on turf, ornamentals, forest lands and shade trees are discussed in this report. Specific techniques and methods are documented in selected references, exhibits and other appropriate sources of information. All available references using similar procedures and methods are not cited in order to avoid repetition. Those cited contain generally accepted protocols and methods, but it is realized that they are not all-inclusive and other references may include different methods or variations of those presented here.

The scope of organizing test methods for turf, greenhouse,saran and outdoor ornamentals, shade trees and forest lands is briefly addressed in the following paragraphs.

TURF

Turf throughout the country provides a fairly uniform habitat for invertebrates and creates a situation where methods used for evaluating pesticides on turf pests such as grubs, sod webworms and chinchbugs are basically similar in many respects. Such factors as insect population densities, soil types and conditions, and turf quality have resulted in variations of basically similar methods or completely novel approaches. Accepted and commonly-used methods to evaluate pesticide effectiveness on other turf pests such as mole crickets, hyperodes and vegetable weevils, flea beetles, frit flies, millipedes, centipedes, sow bugs, slugs and snails, are not readily available.

GREENHOUSE AND SARAN FLORICULTURAL CROPS

It is nearly impossible to produce a commercially acceptable floricultural crop without conducting an effective pest control program. Approximately 30 species of insects and mites are capable of causing problems on greenhouse ornamentals and vegetables, (Smith and Webb 1977). Many of these species plus others attack floricultural crops grown under saran or in the field. There is also a great number of plant species (plus cultivars) produced.

Many pests attack a large group of plant species while others are quite specific. Methods were written to include as broad a group of pest-host combinations as possible. The investigators using these techniques often will have to adapt a general procedure to a specific pest-host combination.

OUTDOOR FLORICULTURAL CROPS

In many respects, the crops under this category are similar to the greenhouse and saran floricultural crops infested by insects and mite pests. Evaluating pesticides on outdoor floricultural crops is basically similar to the testing methods on turf, greenhouse and saran floricultural crop pests. Plants under this category are grown throughout the year in specific locations and are under attack from pests, so the methods and techniques for testing are specific for each crop.

OUTDOOR WOODY ORNAMENTALS

Woody ornamentals are generally produced in commercial nurseries and are used for landscaping public and institutional buildings, parks, industrial sites, home grounds, etc. Such plants include a nearly infinite and constantly increasing number of cultivars, contained in more than 1000 species, 150 genera and 60 families. Approximately 2000 species of invertebrates attack these plants (Westcott 1973). Because of the large numbers of hosts and pests and the limited number of active researchers, evaluation of insecticides on outdoor woody ornamentals and shrubs is difficult and, therefore, specific test methods for every pest are not available.

FOREST AND SHADE TREES

Approximately one-third of the total land area of the continental United States and coastal Alaska is covered by forests, and about 500 species of insects cause damage to these forest trees. Pesticides are developed to prevent attack or to destroy existing pest populations in these forests. The efficacy of these compounds is evaluated by the Insect and Disease Suppression programs of the U.S. Forest Service and other investigators. The programs evaluate pesticides used on insects that attack shade trees as well as forest trees, and pesticides that are applied to a single tree or thousands of trees in single or multiple applications. The test procedure used is determined by the pest problem under consideration.

References

Smith, F. F., and R. E. Webb, eds. 1977. Biogeographic and agronomic problems relating to the utilization of biocontrol organisms in commercial greenhouses in the continental United States. Pages 89-93 in *Pest Management in Protected Culture Crops*. ARS-NE-85, USDA, Beltsville, Md.

Westcott, C. 1973. *The Gardeners Bug Book*. Doubleday, Garden City, N.Y. 689pp.

GENERAL CONSIDERATIONS

The test methods in this report are suggested for evaluating the effectiveness of pesticides for control of invertebrates on lawns and turf, greenhouse, saran and outdoor floricultural crops, woody ornamentals, and forest and shade trees. These methods are to be used as guides and will require periodic revision and updating. The procedures and methods are organized based on pest group basis due to the large numbers of both invertebrates and host plants involved.

Certain aspects concerning test site location, experimental design, reporting of data including phytotoxicity, and analysis of data are applicable.

Location of Test Site: -- Outdoor application sites should be selected where known infestations exist and should reflect variations in environmental conditions which may be encountered.

Greenhouse or saran applications, due to their respective protected environments, are similar regardless of geographic location. Normally, data from three major locations (north central - east, south and west) are adequate as long as they cover the range of variation in cultural conditions likely to be encountered.

Experimental Test Design: -- A sound experimental test design should be used to reduce variability but yet be practical. Random observation or pre-treatment counts may be used to determine population distribution and/or to provide guidance in establishing plot location. Experimental designs generally used are randomized complete block design, completely randomized design or Latin square.

Generally, 4-6 replicates are desirable, but 3 may provide adequate data. There are cases where neither of these criteria may be met, due to limited plant availability, size of area infested and uniformity of the infestation. Larger numbers of replications may be used when an infestation is sparse and uneven. In cases such as greenhouse testing, where an entire greenhouse may be fumigated, a series of individual trials over a period of time utilizing a single greenhouse may provide adequate data.

Poe and Green (1974) studied the effects of several factors (cultivar, fertilization, irrigation practices) on insect and mite pests of chrysanthemums. They recommended that the usual practice of maintaining a completely untreated adjacent check plot should be replaced by a standard material or management practice. Extremely high insect populations in the untreated plots resulted in many pests migrating into treated areas and giving false results on the effects of various treatments.

Reporting of Data: -- A thorough and complete reporting of test data is essential to draw conclusions concerning the effectiveness of a pesticide. Refer to the Guidelines for Registering Pesticides in the United

States for desired variables that should be reported. All parameters addressed in the General Considerations and those specific considerations incorporated into each test method should also be reported. An example of a data report form is provided.

SAMPLE TEST FORM

Experiment Evaluation Report

Expt. No. Investigator:

Physical Layout

Crop: Date Set:

Variety: Stage of Plant Treated:

Location: Soil Type:

Harvest: Date:

Experimental Design

Plot Size: Treatment Dates:

No. Plants: Target Pest:

Replications: Stage Treated:

Means of Application: Nozzle No. Type:

Evaluations

Sample: Dates:

Product Applicability: Phytotoxicity:

Compatability: Environmental Impact:

Effect on Non-Target Organisms:

Efficacy Data

Materials	Form	Rate lb/100 GPA	

Phytotoxicity

On ornamentals and turf, phytotoxicity, the visible response of the plant to some external factor is important when evaluating pesticides. Phytotoxicity is a symptomatic result of what may be a single factor or a complex of several factors. Environmental conditions (temperature, humidity) can aggravate a situation and result in product injury only under those specific conditions. Plant stress, either environmental, nutritional or water, may be cause for concern when applying pesticides safely to plants. In some cases, these variables can be controlled and in all cases should be noted as part of the experimental data. The more common variables utilized in phytotoxicity evaluations follow.

Evaluation of Phytotoxicity

Application Rates: -- Rates should include X (recommended), 2X and 4X, either by volume or by unit area treated.

Application Frequency: -- Apply at intervals necessary to control pest(s), and twice as often as would normally be necessary. The exact intervals are left to the discretion of the researcher.

Method: -- Materials should be used in a manner similiar to conventional practices and as prescribed by the manufacturer.

Plant Material, Growth Stage, etc.

All major stages of plant growth (seedling, vegetative, flowering) on which the pesticide is expected to be used should also be included. In addition, trials should be conducted during all seasons that the host plant is produced and subject to pest attack.

Examples of most common and/or most easily damaged cultivars must be included in phytotoxicity trials. The number of cultivars to be included will vary with ornamental or turf plant species, region of the country and season of growth.

Measurement of Plant Response

Plant Growth Response: -- Any growth deviating from what is expected or normal judging by past performance should be measured, since this may represent a response of a plant or portion of a plant to a stress situation. The definition of what is "normal" may vary considerably, and usually is interpreted within broad limits. Deviations should be observable in each replicate of a treatment.

Typical plant responses to pesticides include leaf deformity (Fig. 1a), leaf drop, growth reduction (or stimulation), reduced flower production —— number or quality (Figure 1b), and a general change in leaf character (e.g., "hardening" of tissues), chlorosis (Fig. 1c), discoloration, or color alteration.

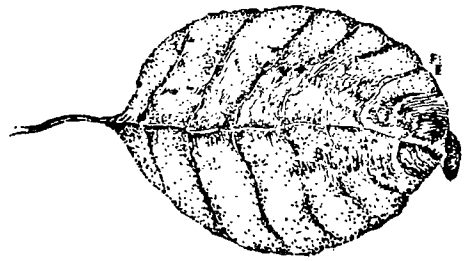

Fig. 1a: Leaf showing symptoms of deterioration

Fig. 1b: Reduction in flower quality caused by spotting of petals

Fig. 1c: Chlorosis around leaf margins

Chlorosis: -- In this condition, the normal green color disappears and leaves become pale green, yellow, white, orange or reddish depending on remaining pigments. Symptoms can vary widely in area of leaf affected and intensity from a slight loss of green color in local areas of the leaf to a faint mottling or a uniform pale green appearance. More severe chlorosis results in general yellowing, or the entire leaf becomes pale, yellow or bleached. Chlorotic tissue may recover in time or can retain symptoms throughout the life of the plant. Some products cause symptoms on portions of the plant treated and on new growth that appears after treatment.

Marginal chlorosis probably is the most common form, but interveinal chlorosis also occurs frequently.

Another type of chlorosis (Fig. 1c) appears when cells below the leaf epidermis are killed and the epidermis separates from the mesophyll. This results in symptoms called glazing, bronzing or silvering.

Necrosis: -- Necrosis means death, and can include individual cells, specific parts of leaves (Fig. 1d), buds, roots or entire plants. Sometimes initial symptoms of chlorosis progress into necrosis. Color expressed by necrosis can vary from pale yellow or white to dark brown, depending upon the type of cell affected, how fast it died, and what killed it. In all cases, necrosis is irreversible and the tissue affected never recovers.

As with chlorosis, leaf margins are usually affected first. Symptoms can then extend inward toward the midrib, and possibly affect the entire leaf. Necrotic spots also are common and variable in size (Fig. 1e).

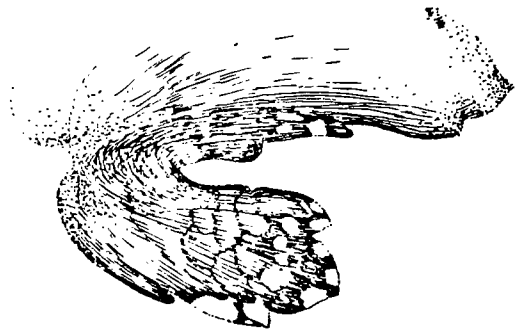

Fig. 1d: Leaf showing large (necrotic) area in center

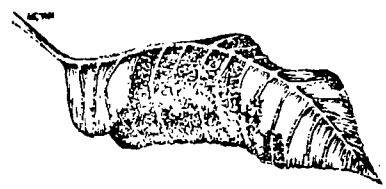

Fig. 1e: Leaf showing necrotic spots

Necrosis of stems or shoots is called dieback. Other common terms include "burn", "scorch", "spotting".

Regardless of type of symptom(s), any effects of pesticides should be fully described, e.g., extent of necrotic/chlorotic areas as a percent of leaf or plant affected, or portions of plant affected. Often only parts of uniform age or development are symptomatic. Not only should the area or portion of the plant affected be noted, but the degree or intensity of damage is important. A subjective rating from a visual examination may be developed to ascribe a numerical value to the damage based on intensity of symptoms (Fig. 2). A 0-3 scale is appropriate: 0 - no damage observed; 1 - mild symptoms but considered marketable under most conditions; 2 - moderate damage symptoms with definite market value decrease; 3 - severely damaged, definitely unmarketable.

Fig. 2: Types of phytotoxicity that can be quantified using a numerical rating system to illustrate level of damage

Visible effects may be immediate, or may not appear for several days or weeks after application. Often only one application of a pesticide will result in symptoms, but more than one may be necessary. Researchers should observe treated and untreated plants closely for a season or through the growth cycle of one crop.

Obviously, not all plant cultivars, pesticide rates, treatment intervals, plant growth stages, environmental conditions, etc., can be included in experimental work. What is necessary are data showing a pesticide to be safe to most plants on which it is applied under conditions where it will commonly be used. Specific conditions of the experiment, however, should be recorded.

Phytotoxicity data are especially pertinent since a product registered for use against a pest on one host may be registered for use against that pest on another host, providing that phytoxicity data indicates plant tolerance.

Analysis of Data: -- Statistical analysis of data should be applied wherever possible using a valid statistical test. If significant differences are obvious without analysis of variance, a comparison of means may suffice. Evaluation of results usually involves counting the number of pests which survive the treatment and comparison of this with an untreated check and/or standard commercial treatment (control). Presentation of means and percent control compared to an untreated check or a commercial standard is a common practice.

Additional Considerations: -- Application techniques, sampling techniques, sampling intervals, and pertinent details differing from those provided under General Considerations are described either under the applicable subject area or each individual test method which follows.

Reference

Poe, S. L., and J. L. Green. 1974. Pest management determinant factors in chrysanthemum culture. *Fla. St. Hort. Soc. Proc.* 87: 467-471.

TURF

The test methods for calculating the effectiveness of pesticides on invertebrate pests of turf are organized on a pest group basis, including insects such as chinchbugs, grubs and sod webworms. The comments offered under General Considerations are applicable to these test methods unless otherwise specified.

Chinchbugs

The following procedures have proven successful for evaluation of effectiveness of insecticides for control of chinchbugs: *Blissus leucopterа hirtus* Montandon and *Blissus insularis* Barber.

Experimental Design: -- The experimental design commonly used to test the effectiveness of insecticides, which yields data suitable for simple statistical analysis utilizes a 3m x 3m (equivalent to 10' x 10') plot (Kerr 1962, Polivka 1963, Reinert 1972, Streu and Cruz 1972) with treatments arranged in a randomized complete block design (Kerr 1962, Reinert 1972, Streu and Cruz 1972). Pretreatment counts are usually taken for the purpose of establishing population uniformity and to provide guidance in establishing the experimental design (Kerr 1962, Reinert 1972, Streu and Cruz 1972). Alleyways between plots are desirable to prevent pesticide contamination when applying treatments, but are not always practical.

Application Methods: -- Granular formulations are usually applied by using a shaker can (Reinert 1972) or a lawn fertilizer spreader (Polivka 1963). Wettable powder and emulsifiable concentrate formulations are mixed with water and usually applied with a sprinkling can (Reinert 1972, Polivka 1963), but may be applied with a pressurized sprayer or other suitable calibrated applicator. Watering plot areas prior to treatments to moisten the turf and/or thatch is a desirable practice (Kerr 1962). It is not always applicable due to turf conditions, thatch thickness, etc., and may also depend upon whether liquids or granules are being applied. Watering plot areas following application (Kerr 1962, Reinert 1972, Streu and Cruz 1972) is a common practice where applicable, for the purpose of washing the insecticide into the zone of insect activity.

Sampling and Counting Techniques: -- Chinchbug counts are taken by forcing a metal cylinder (open at both ends), covering an area of approximately 0.06 m^2 to 0.09 m^2 (equivalent to 2/3 - 1 sq. ft.), into the turf (Kerr 1962, Reinert 1972, Streu and Cruz 1972). The cylinder is filled with water and the live chinchbugs which float to the surface in a 7-10 minute period are

counted (Kerr 1962, Reinert 1972, Streu and Cruz 1972). One (Kerr 1962, Reinert 1972) to three (Streu and Cruz 1972, Polivka 1963) samples may be taken per replication. Actual counts should be recorded. In high-density populations, such as those that occur in Florida, counts in excess of 100 chinchbugs are recorded as 100, and counting stopped at that factor (Reinert 1972). Morishita, et al. (1969) found that a D-Vac machine was the most efficient of several sampling methods tried.

Sampling Intervals: -- Counts of live chinchbugs should be taken within a 7-day period (Reinert 1972) following application, to provide a measure of initial kill. Subsequent counts may be taken on a one (Reinert 1972), two (Kerr 1962, Streu and Cruz 1972) or four to six (Polivka 1963, Streu and Cruz 1972) week intervals, extended over a period of time sufficient to determine the residual effectiveness of the treatments.

References

Kerr, S. H. 1962. Lawn insect studies —— 1962; Chinchbugs. *Proc. Annu. Fla. Turf-Grass Manage. Conf.* 10: 201-208.

Morishita, F. S., R. N. Jefferson, and L. Johnson. 1969. Southern chinchbug, a new pest of St. Augustine grass in southern California. *Calif. Turf-Grass Culture* 19(2): 9-10.

Polivka, J.B. 1963. Control of hairy chinchbug, *Blissus leucopterous.* Mont., in Ohio. *Ohio Agric. Res. Dev. Cent. Res. Circ.* 122: 1-8.

Reinert, J. A. 1972. Control of the southern chinchbug, *Blissus insularis,* in South Florida. *Fla. Entomol.* 55(4): 231-235.

Streu, H. T., and Carlos Cruz. 1972. Control of the hairy chinchbug in turf-grass in the northeast with Dursban insecticide. *Down to Earth* 28(1): 1-4.

Grubs, Weevils and Scarabs

The following procedures have proven successful for evaluation of effectiveness of insecticides for controlling larval stages of the Japanese beetle, northern and southern masked chafers, European chafer, Oriental beetle, Asiatic garden beetle *Phyllophaga* sp., and weevils.

Experimental Design: -- A commonly used experimental design to test the effectiveness of insecticides for control of grubs utilizes plot sizes ranging from 3 m x 3 m (10' x 10') to 7.5 m x 7.5 m (25' x 25') (Dunbar and Beard 1975, Gambrell et al. 1968, Tashiro and Fiori 1969). This allows for sampling and resampling at periodic intervals. Treatments are usually arranged in a randomized complete block design (Dunbar and Beard 1975, Tashiro and Neuhauser 1973) and this will yield more dependable results.

Application Methods: -- Granular formulations may be applied with a shaker can (Polivka 1965) or a lawn fertilizer spreader (Dunbar and Beard 1975, Tashiro and Neuhauser 1973). Liquids from wettable powders and emulsifiable concentrates should be mixed with water and applied with a sprinkler can (Dunbar and Beard 1975, Polivka 1965, Tashiro and Neuhauser 1973) pressurized sprayer or other suitable calibrated applicator. The method used should provide thorough coverage of the plot area at the desired rate of application. This may be accomplished by applying premeasured amounts to each plot, in two directions at right angles to each other (Tashiro and Neuhauser 1973).

Watering plot areas prior to treatments to moisten the thatch and/or soil is a desirable practice. It is not always applicable due to the turf conditions, thatch thickness, etc., and may also depend upon whether liquids or granules are being applied. Where applicable, plots should be watered thoroughly following application of treatments (Dunbar and Beard 1973, Tashiro and Fiori 1969).

Sampling Techniques: -- Since grubs generally feed on the roots of plants in the turf, a tool for digging is required to sample. Several available tools are suitable, such as a 175 mm x 175 mm (7" x 7") ice scraper, a 100 mm (4") diameter cup cutter and mechanical sod cutters.

The depth of the sample can be determined by the thickness of the turf and the depth of the grubs. To provide data suitable for analysis, randomly select sample sites three to ten per plot (Dunbar and Beard 1975, Polivka 1965, Tashiro and Fiori 1969). Generally, a total area of not less than 0.09 m^2 (1 ft^2) per plot is desired, utilizing sample sizes such as 100 mm (4") diameter (Polivka 1965), 160 mm (6.4") diameter (Dunbar and Beard 1975) and 175 mm x 175 mm (7" x 7").

Niemczyk and Dunbar (1976) reported that density, moisture content, and depth of thatch over the target pests should be recorded. Their data indicated that variation in these factors may explain inconsistent results obtained in some experiments with nonpersistent insecticides.

Niemczyk (personal communication 1977) also stated that type of turf, soil pH, percent of various growth stages of the pest present at the time of treatment and amount of water applied posttreatment are very important and should be reported when presenting data.

Counts of living insects in each sample should be recorded.

Sampling Intervals: -- Parameters of individual tests will determine the intervals for sampling. Spring or summer treatments during the period of activity may be evaluated one to three weeks following application to determine initial kill or on four, six or eight week intervals (Dunbar and Beard 1975, Tashiro and Neuhauser 1973) to determine effectiveness and/or residual activity of the insecticide. Generally, summer applications

(July through August) directed at killing young insects are evaluated in the fall (September through October) when remaining larvae are large enough to be readily found and soil moisture is adequate to allow for proper sampling and examination (Tashiro et al. 1971). Counts on longer-term studies following a spring, summer or fall treatment may be taken from a nine to twelve month period or longer intervals (annually to determine residual control activity) (Gambrell et al. 1968).

References

Dunbar, D. M., and R. L. Beard. 1975. Japanese and oriental beetles in Connecticut. *Conn. Agric. Exp. Stn. Bull.* 757: 1-5.

Gambrell, F. L., H. Tashiro, and G. L. Mack. 1968. Residual activity of chlorinated hydrocarbon insecticides in permanent turf for European chafer control. *J. Econ. Entomol.* 61(6): 1508-1511.

Niemczyk, H. D. 1977. Personal communication. OARDC, Wooster, Ohio.

Niemczyk, Harry D., and Dennis M. Dunbar. 1976. Field observations, chemical control, and contact toxicity experiments on *Ataenius spretulus*, a grub pest of turf grass. *J. Econ. Entomol.* 69(3): 345-348.

Polivka, J. B. 1965. Effectiveness of insecticides for control of white grubs in turf. *Ohio Agric. Res. Dev. Cent. Res. Circ.* 140: 1-7.

Tashiro, H., and B. J. Fiori. 1969. Susceptibilities of European chafer and Japanese beetle grubs to chlordane and dieldrin: suggesting reduction in application rates. *J. Econ. Entomol.* 62(5): 1179-1183.

Tashiro, H., K. E. Personius, D. Zinter, and M. Zinter. 1971. Resistance of the European chafer to cyclodiene insecticides. *J. Econ. Entomol.* 64(1): 242-245.

Tashiro, H., and W. Neuhauser. 1973. Chlordane-resistant Japanese beetles in New York. *N.Y. Agric. Exp. Stn. Ithaca Mem. Search Agric.* 3(3): 1-6.

Spittlebugs

Most published spittlebug control work has been done on pasture grasses, however methods should be readily adaptable to turf.

Experimental Design: -- Randomized complete block experimental design with four replications in 300-375 mm (12"-15") high pasture grass (Pass and Reed 1965).

Application Methods: -- Materials may be applied as sprays in 57 l (15 gal.) water per acre, or as granulars broadcasted (Pass and Reed 1965).

Evaluation: -- Numbers of spittlebugs are determined in a 0.9 m^2 (1 $yd.^2$) area of each plot. Counts are made one, three and seven days after treatment (Pass and Reed 1965).

References

Pass, B. C., and J. K. Reed. 1965. Biology and control of the spittlebug *Prasapia bicincta* in coastal Bermuda grass. *J. Econ. Entomol.* 58: 275-278.

Mole Crickets

Mole crickets are highly mobile subterranean insects that damage turf by their tunneling activities in the root zone and by their appareant feeding. Insecticides have been used as granules, baits, sprays and drenches.

Experimental Design: -- Commonly used design in turf or on golf courses utilizes plots that are from 3 m to 7 m square. Plots are bordered on all sides by an untreated zone 1 m to 3 m wide and roped off with strings or otherwise clearly marked. Four replicates are treated in a randomized block design (Habeck and Kuitert 1964, Short and Driggers 1973, Barry and Suber 1975).

Application Methods: -- Insecticides are applied as baits, sprays, granules, or drenches, and may be watered in by irrigation (Habeck and Kuitert 1964, Short and Driggers 1973). Materials can be dispersed by hand, compressed air sprayer, or by sprinkler cans.

Evaluation Techniques: -- Different methods have been used. The most common method is to count dead and moribund crickets on the turf in in each plot. Counts are made for four to seven days after treatment. A second method is to drench a 1 m^2 area with 1% pyrethum and count the crickets that emerge within 15 minutes. A third method has been to count surface burrows in open spaces after irrigation or rain.

References

Barry, R. M., and E. F. Suger. 1975. Field evaluation of insecticides for mole crickets in turf. *J. Georgia Entomol. Soc.* 10: 254-249.

Habeck, D. H., and L. C. Kuitert. 1964. Mole cricket control studies. *Sunshine State. Agr.: Report for January*. pp. 11-12, 20.

Short, D. E., and D. P. Driggers. 1973. Field evaluation of insecticides for controlling mole crickets in turf. *Fla. Entomol.* 56: 19-23.

Lepidopterous Larvae

Grass loopers of the genus *mocis* and other turf foliage feeding Lepidoptera (*Spodoptera*) have been treated for control.

Experimental Design: -- Plots may be laid out similar to that for mole crickets (see previous section) or where larger acreages are involved, three 18 m bands across 8 ha of coastal bermuda have been found adequate (Koehler et al. 1973).

Application Method: -- A Cessna Ag truck with a transland spray system equipped with 60 DG and 30 DG nozzles to apply material in 18 m wide bands may be utilized (Koehler et al. 1973).

Evaluation Techniques: -- Pretreatment and posttreatment counts at 0, 24, and 72 hours should be conducted. Each sample should consist of 0.4 m^2 areas of the treated area, selected by tossing a 0.6 m x 0.6 m plastic pipe frame into each treatment area. Larvae are collected and counted from inside the frame area (Koehler et al. 1976).

References

Koehler, P. G., R. J. Gouger, and D. E. Short. Control of striped grass loopers and armyworms in pasture: 1976. *Fla. Entomol.* (In Press).

Sod Webworms

Experimental Design: -- Plots of 4.7 m^2 (1.5 m x 3.0 m), bordered by a .6 m buffer zone on all sides are randomized in blocks with 4 replications per treatment. Blocks are laid out according to pretreatment infestation level and bordered by 0.5 m buffer zone (Reinert 1972, 1974).

Application Method: -- Granular insecticides are dispersed with a hand shaker and watered in with 7.6 l water per plot. Spray materials are applied in 1-2 l water with a hand sprayer (Reinert 1972, 1974).

Evaluation Technique: -- Sod webworms are counted by sprinkling 1 of a 0.02-0.05% pyrethrum on a 0.6 m x 0.6 m section of each plot and counting the larvae that emerged in 10 minutes (Reinert 1972, 1974).

References

Reinert, J. A. 1972. Sod webworm control in Florida turfgrass. *Fla. Entomol.* 56: 333-337.

Reinert, J. A. 1974. Tropical sod webworm and southern chinchbug control in Florida. *Fla. Entomol.* 57: 275-279.

Margarodid Scales

These scales, commonly known as ground pearls, attack turf in the thatch and soil-root zone.

Experimental Design: -- Experimental units may consist of 1.5 m x 1.5 m plots divided into 5 blocks (Short 1973) selected in areas of turf known to be infested with ground pearls. 4 replications of each treatment are necessary.

Application Method: -- Materials may be applied as granules with a hand shaker (bottle or can), or as sprays dispersed with a compressed air sprayer. Application is followed by irrigation to move materials into the root zone (Short 1973).

Evaluation Techniques: -- Samples consisting of 10 25 mm cores of soil 12.7 cm deep are taken from each plot and placed in a 1000 ml Erlenmayer flask fitted with 0.4 molar sucrose. A rubber cork, just small enough to pass through the neck of the flask is placed in the flask with a 30.5 cm wire attached. The soil samples are stirred in the sucrose intermittently for 5 minutes, after which the cork is pulled from the flask by the wire, removing from the flask neck all the floating scales. The collection is lifted onto checkered cloth over a coffee can, rinsed and transferred to a binocular microscope for counting.

Samples are taken at intervals after treatment for up to one year. Results are compared with pretreatment counts.

References

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GREENHOUSE, SARAN AND OUTDOOR FLORICULTURAL CROPS

Methods outlined are designed so that insecticides and acaricides can be evaluated against insects and mites on the following general crop groups. (Crops listed are examples of major crops within each group.)

- Flowering Plants

  Azalea, rose, poinsettia, gardenia, chrysanthemum, carnation, snapdragon, aster, geranium, orchid, African violet, Easter lily, iris (including bedding plants)

- Foliage Plants

  Ficus, palms, Schefflera, Dracaena, ferns, Philodendron, Pothos, sansevieria

After data are obtained that show a material to be effective in controlling a pest on one crop within a group, that material may be considered effective against that pest on all crops where it occurs within the group. However, adequate phytotoxicity data must be obtained on all crops on which a material is to be used.

These methods have been gathered from several sources, and documented by published and unpublished reports. Cited material is only to serve as a guide for a procedure and often many more references containing the same or similar procedures could have been listed.

Application Techniques and Equipment: -- Many researchers use small compressed air sprayers (capacity 3.8 - 7.5 liters = 1-2 gallons) to disperse materials. Others simulate high-volume sprays by dipping leaves or plants into insecticide solutions or suspensions (Henneberry and Smith 1965, Webb et al. 1974), or by using small hand-held aerosol propellant cans to spray plants (Lindquist 1974). The common element in all applications is coverage to the point of runoff and no matter which method is used, data obtained from these tests may be used to support results of larger, commercial trials, if proper sampling and adequate replication is used. However, at least one trial must be conducted with equipment used in commercial plant production to substantiate results.

For most pests of floricultural crops, it is particularly important to direct sprays at the undersides of leaves to contact surfaces where pests are generally found.

Granular insecticides usually are scattered evenly over the soil surface of plant beds or pots or over foliage of closely-spaced plants. Application rates for granular materials are calculated either on the basis

of surface area or on volume of soil (Smith 1952). Both procedures may provide adequate efficacy data, depending upon the objectives of the experiment. Following application, water is applied to wash off any granules adhering to foliage and to carry the toxicant down to the root zone. Applications may be made with a shaker jar or broadcast spreader that does not grind the granules.

Liquid systemic insecticides are usually applied to the media of pots or plant beds. Enough solution is applied to carry the toxicant to the root zone (Neiswander 1962).

Aerosols, fumigants, fogs (thermal and non-thermal) are applied at a certain rate per cubic meter, with the appropriate specialized application equipment.

Location of Tests: -- A minimum of three distinct geographical regions is necessary.

Greenhouse and Saran: -- Geographical variation is not as critical as in field tests, but because of some differences in climate and cultivars produced, data should be obtained from the three major producing areas (West, Southwest, North Central-East).

Plot Size: -- Plot size may vary depending upon available plant material, numbers of materials included in the test and whether trials are conducted in a research or in a commercial operation.

For preliminary, or supplemental testing with insecticides, data obtained in replicated tests with only 1-3 plants per replicate may be considered valid if other test parameters are adequate (Webb et al. 1974, Lindquist 1975). These data may be used as supportive, but should not be considered "primary". At least one trial must also be conducted under commercial growing conditions with commercial equipment to validate data obtained in small plot tests. Before and after treatment counts can be used to obtain efficacy data where only low thresholds of damage are tolerable.

Replication: -- Four replicates are preferred, but at least 3 replicates of each treatment are necessary for statistical analysis. In aerosol or other fumigant applications, where an entire greenhouse must be treated, a series of 3-4 trials over a period of time provides a means of replication when insufficient area is available for replication at one time.

Sampling: -- Pretreatment counts are often made to establish the presence of an infestation before selecting plants to be treated or as an aid in designing the experiment. These counts are not always necessary nor are they always included in tabular results.

In some tests, e.g., with aerosols, fumigants, fogs, etc., pretreatment counts are necessary to establish the efficacy of a treatment. For these treatments, a known number of insects or mites may also be put in cages and placed in different areas of the greenhouses to measure efficacy.

It is essential to have temperature records, especially at times when treatments are applied. These data should provide information on the effectiveness of a material over a range of temperatures or a clue as to why phytotoxic symptoms appeared.

Phytotoxicity: -- Refer to Phytotoxicity section in General Considerations.

References

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APHIDS

For methods and other information applicable to testing insecticides against all insects on floricultural crops, see both General Considerations and the introduction to the Floricultural Crops Section.

Most methods cited concern the green peach aphid, *Myzus persicae*, on greenhouse chrysanthemums. This aphid also infests many other hosts, but little information is available for test methods on these hosts. Other common aphids include the rose aphid, *Macrosiphum rosae*, potato aphid, *Macrosiphum euphorbiae*, and chrysanthemum aphid, *Macrosiphoniella sanborni*. Several other species can and do occur (Hussey et al. 1969).

Because the green peach aphid is the most common species and the most difficult to control (Hussey et al. 1969), efficacy data obtained on a material for controlling this species may also indicate the effectiveness for that material in controlling other species.

Sampling of Treated Population

Aphids on Leaves, Stems and Terminal Shoots: -- Sampling methods can be divided into several basic types, including counting aphids on entire plants (Gould 1969, Webb and Smith 1973), or on leaves (Helgesen 1971, Poe and Marousky 1971, Poe and Green 1974). Counting aphids on entire plants should eliminate any variation in location of aphid populations on different cultivars of a host (Markkula et al. 1969, Webb and Smith 1973). However, if samples are taken from the same location on all plants, this potential source of bias may be eliminated.

Another sampling method which may be used is counting aphids on stems, or recording stems and/or terminal shoots as infested or not infested. Sometimes recording stems or shoots as infested or not infested is combined with a weighted rating system to give an estimate of the severity of infestation (Overman and Poe 1971, Lindquist 1972). Because aphids in greenhouses are all females that give birth to living young without mating, the presence of one or more aphids on a stem leaf, or flower indicates that there is the potential for a severe infestation (Hussey et al. 1969).

A known number of aphids may be introduced onto previously uninfested plants just prior to treatment (Helgesen and Tauber 1974).

Aphids in Flowers: -- Often, controlling aphids in open flowers is necessary before plants are sold, or insecticides are applied to prevent flowers from becoming infested. Recording the number of flowers with and without aphids (Appleby 1972), the number of live aphids in a number of flowers (Lindquist 1974), or using an extraction technique to separate aphids from flowers (Gray and Schuh 1941) should provide adequate efficacy data.

Because aphids are capable of migrating into greenhouses from outdoor plantings, or moving around within greenhouses (Dixon 1971), it often is necessary to obtain an estimate of a material's residual killing power. This may be achieved by placing infested plants among treatments, using untreated check plants as the potential source of a new population, or to reinfest plants at intervals after treatments have been applied (Gould 1969). This latter procedure should provide the most reliable data on residual effectiveness, because aphids are not always in a migratory (winged) stage.

References

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MEALYBUGS AND SOFT SCALES

For methods and other information applicable to testing insecticides against all insects on floricultural crops, see both General Considerations and introduction to the floricultural crops section.

Foliar Feeding Mealybugs and Soft Scales

Experiments may be conducted with naturally-infested plants, or pests may be transferred to uninfested plants by placing heavily infested plants or foliage in contact with the uninfested plants (Hamlen, 1975).

A laboratory procedure with excised leaves placed in a specially constructed bioassay chamber may be utilized (Hamlen 1975).

Insecticide Application: -- Spray materials are applied to runoff with either small compressed air equipment or commercial sprayers, depending on the number of plants to be treated.

Soil drenches or systemic granular materials are applied as described in the introductory section of floricultural crops. The number of applications and interval depends on pest species and residual life of the pesticide.

Evaluation of Results: -- Pretreatment counts are utilized (Hamlen 1975a, b, 1977). Mealybugs are sampled by agitating 3 leaves detatched from basal, mid, and upper foliage for 5 sec. in 30 ml water containing 2 drops of surfacant, and counting the mealybugs removed. Counts are made 5 days posttreatment and at 14-day intervals. Other counts are made by examining entire plants.

Hemispherical scales (*Saissetia coffeae*) are recorded (Hamlen 1975) from 3 leaves removed from basal, middle and upper portions of each plant at 14 weeks posttreatment, or by recording live adults on entire plants at monthly intervals. The number of scales appearing on previously uninfested foliage also are used in evaluations.

Root Mealybugs, *Rhizoecus* spp. on Container-Grown Floricultural Crops

Insecticide Application: -- Depending on the insecticide formulation used, 3 application methods are employed.

- Spreading granules on soil surface (Poe, 1972, Poe et al. 1973, Hamlen 1974).
- Applying liquid suspensions as soil drenches (Poe 1972, Poe et al. 1973, Hamlen 1974).
- Submerging pot and root ball for a certain amount of time (5 minutes) in insecticide suspensions (Poe 1972).

Evaluation of Results: -- Mealybug populations are measured by lifting each plant from its container and counting individuals lying adjacent to the exposed roots on the outside of the root ball (Poe 1972). These counts may be made in a restricted band (Hamlen 1974).

Counts made beginning 7 days posttreatment (Poe 1972), and at weekly or biweekly intervals thereafter (Hamlen 1974).

Reporting Tabular Data: -- Efficacy may be reported as percent control, compared with untreated checks (Poe 1972), or mean number individuals per plant (Hamlen 1974).

References

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WHITEFLIES

For methods and other information applicable to testing insecticides against all insects on floricultural crops, see both General Considerations and introduction to the floricultural crops section.

Most of the emphasis is on evaluation of materials to control the immature stages (egg, nymphs, "pupae" - the last nymphal instar), rather than the adult stage. There are two reasons for this. First, the adult is susceptible to many materials, and although it is desirable to control this stage, a material is more valuable if it controls the developing nymphs because fewer applications will be necessary. Second, adults are able to fly among the treatments, and mortality is difficult to assess unless treatments are separated by some physical barrier (screens, separate greenhouse compartments, etc.). Therefore, beyond rather immediate killing power of a material, residual effects on adults are difficult to measure.

Obtaining Test Insects

Greenhouse whitefly populations usually are readily available in most greenhouses, and few specific rearing instructions for the insects should be necessary. However, large numbers of whiteflies can be reared on tobacco plants, or on the specific host plants to be used in the tests. Rearing

should be done in a separate greenhouse compartment or caged area within a compartment, and the adult population used to obtain life stages of known age (Smith et al. 1970, Webb et al. 1974).

Because whiteflies normally develop from the apical portion of the plant downward on undersides of leaves, similar age group distribution may be obtained by selecting these areas to make counts (adults and eggs on apical leaves, nymphs and pupae on subapical leaves).

Sampling of Treated Population

Adults: -- Sampling adult populations normally involves counts from a certain number of apical leaflets (Lindquist 1972), on the entire plant (Webb et al 1974), or on blackened glass plates (or paper) placed among the plants (Smith et al. 1970, Webb et al. 1974). All of these procedures may give reliable data on whitefly adult mortality. Residual killing can only be measured by using glass plates or paper, or by caging adults on treated leaves at intervals after application (Kreuger et al. 1973). If glass plates or paper are used, dead adults must be removed each time data are recorded. The other methods give only estimates of immediate kill, unless treatments are physically separated by a barrier (cages) or in separate greenhouses.

In some cases, e.g., aerosol or fumigation trials when materials must be applied to an entire greenhouse compartment, pretreatment and posttreatment counts will be necessary (Lindquist 1974).

Nymphs and Eggs: -- There are many procedures used to evaluate control, or mortality, of whitefly immature stages. Procedures mentioned here may be used to develop reliable data, with adequate replication.

Recording life stages from entire leaves, leaflets, or per unit of leaf area can be done if the same plant species (or cultivar) is utilized for efficacy trials (Smith et al. (1970), Webb et al. (1974), Krueger et al. (1973), Lindquist (1974), and Schuder (1974)).

To record life stages from portions (e.g., 1/2) of leaves, the criteria apply as above.

Recording life stages from uniform-sized leaf discs or punches should give the best estimate of populations if several cultivars of the same species or several different species are included in a trial, because the area sampled will be equal for all plants. Discs or punches should be removed from the same relative areas on all plants to ensure a uniform age distribution of sampled population.

Record the number of live and dead life stages in the first 50 or 100 encountered (Webb et al. 1974).

Recording of Efficacy Data

Adults: Adults may be recorded as number alive per sampling unit (leaf, leaflet, plant), or number dead per glass plate or paper square.

Immature Stages: -- These data may be recorded in several ways (Smith et al. 1970). Count live nymphs plus empty "puparia" (i.e., adults had emerged) (Schuder 1974). This procedure should provide adequate data if pretreatment observations establish that only young nymphs are present.

Intervals after treatment for recording data may vary. Adult mortality may be measured within a few hours, but if effects on immature stages are to be measured, it will be necessary to wait at least 7 days before any effects are noted. Appropriate intervals are described by Smith et al. (1970), Allen (1972), Schuder, (1974).

References

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THRIPS

Several species of thrips injure foliage, flowers and below-ground parts of floricultural crops. The methods outlined below should provide adequate data against species likely to be encountered.

For general methods and statements concerning insect and mite control on floricultural crops, see both General Considerations and introduction to the floricultural crops section.

Flower Thrips, *Frankliniella* spp., in Open Flowers

Sampling Methods: -- Sampling treated flowers may be divided into three basic methods, which are described below.

1. The Wash Method (Taylor and Smith 1955, Ota 1968). This procedure involves tearing flowers apart in a detergent solution, allowing flower parts to float to the top and thrips to settle out, then pouring the mixture through a series of different sized screens to separate the thrips from the fluid.

2. The Mechanical Method (Henneberry et al. 1964). Infested rose flowers are torn apart, placed in a plastic container with a screen bottom, and shaken over a wet black cloth.

3. The Irritation Method (Evans 1933). An irritant, such as turpentine, ethyl acetate, or methyl isobutyl ketone is used to drive thrips out of infested flowers and into a pan of water or onto a paper coated with a sticky substance. Another technique is to use a Berlese Funnel to drive thrips into an alcohol solution (Schuder 1974, Morishita 1975).

Reporting of Results: -- With all of the techniques above, results are reported as number of thrips per flower, or groups of flowers.

Sampling Interval: -- After applications of an insecticide, the first samples usually are taken one day after treatment (Henneberry et al. 1961, Lindquist 1972, Schuder 1974). Following this initial sample, subsequent counts to measure residual action may be made at the discretion of the researcher.

References

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Gladiolus Thrips

This thrips attacks corms, foliage and flowers of galdiolus. Individuals may survive on corms in storage and be transplanted into fields. Consequently, it is necessary to treat corms and plants, and to protect flowers from the gladiolus thrips.

Experimental Design: -- 25 single or double row plots or 100 large corms may be utilized as an experimental unit (Schuster and Wilfret 1975). Four replicates per treatment block are treated in a randomized fashion. With corms 3 corms per replicate are treated with each treatment replicated 6 times.

Application Methods: -- To field grown plants weekly applications are made for 7 weeks with a compressed air sprayer. Corms are dipped in pesticide solutions for 10 or 30 minutes (Schuster and Wilfret 1975).

Evaluation Techniques: -- Plant populations are estimated in flowers from 5 spikes cut from each plot. Flowers are cut when color begins to show and held at 80° F for 3 days, then the number of thrips counted in the 5 lowest florets on each spike.

On corms, nymphs and adults are counted 4 or 7 days posttreatment.

References

Schuster, D. J. and G. J. Wilfret. 1975. Evauation of acephate on gladiolus for control of thrips and lepidopterous larvae. *Fla. State Hort. Soc. Proc.* 88: 584-586.

Cuban Laurel Thrips

Cuban laurel thrips, *Gynaikothrips ficorum* (Marchal) caused damage to ornamental ficus by its feeding on foliage which begins on young leaves as sunken red to purple spots along the mid vein. Gradually, the leaf folds in or rolls to form a tight curl.

Experimental Design: -- Infested plants 1.5 m tall in 7.6 l containers are divided into 4 replicates based on level of infestation. Treatments are randomly assigned within the replicates (Reinert 1973).

Application Method: -- Foliar sprays are applied with a 7.6 l compressed air sprayer, granules are applied directly to the containers and washed in with water.

Evaluation Techniques: -- Samples of 8-12 infested terminal leaves per plant are examined and thrips counted before and weekly after application for 7 weeks.

References

Reinert, J. A. 1973. Cuban laurel thrips: Systemic insecticides for control. *J. Econ. Entomol.* 66: 1217-1218.

LEPIDOPTEROUS LARVAE (CATERPILLARS)

For general methods and statements concerning insect and mite control on all floricultural crops, see both General Considerations and introduction to the floricultural crops section.

Obtaining Test Insects: -- Caterpillars can be reared if facilities are available, or shipped from laboratories able to do the rearing. Natural infestations do occur, but may be uneven. Caterpillars or eggs should be evenly distributed among plants to be treated.

Application Methods: -- See General Considerations for applicable information.

Foliar Feeding Caterpillars (Including Leafrollers)

Species that occur on the foliage, flowers, and buds of floricultural crops include the cabbage looper, *Trichoplusia ni*; budworm and corn earworm, *Heliothis* spp.; armyworm, *Spodoptera* spp; and omnivorous leafroller *Platynota stultana*. Other species may be pests on one or more crops.

Evaluation of Results: -- Record the number of living larvae per plant or group of plants (Lindquist 1976, Schuster and Wilfret 1975). Number of damaged plants in a given area is also used to measure efficacy (Schuster and Wilfret 1975). Allen (1967, Exhibit 11) used a time search procedure.

Sampling intervals will vary with the test species and chemical used, but the first counts should be made within 48-72 hours posttreatment.

References

Allen, W. W. 1967. Effectiveness of various pesticides applied as sprays for control of the omnivorous leafroller on greenhouse roses. (Exhibit 11).

Lindquist, R. K. 1977. Using Dipel effectively for caterpillar control. *Ohio Florists' Assn. Bull.* No. 567:8.

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Cutworms

Several species of cutworms may attack floricultural crops, including the black cutworm, *Agrotis ipsilon* and variegated cutworm, *Peridroma saucia*. The variegated cutworm is known as a climbing cutworm because it moves up the plant and feeds on foliage, buds and flowers. All hide in the soil or mulch during the day and feed at night.

Application Methods: -- Insecticides are applied as sprays or baits, generally late in the afternoon before cutworms become active. Sprays are directed at the foliage and root, while baits are broadcast on the soil surface only.

Evaluation of Results: -- Dead larvae may be recorded directly from the soil surface, or a measurement made of plant injury (Lindquist 1977). Data usually are recorded 1 day posttreatment and at suitable intervals thereafter.

References

Lindquist, R. K. 1977. Cutworm control trials on greenhouse crops in 1976. *Ohio Florists' Assn. Bull.* 568: 8-9.

Iris Borer, *Macronoctua onusta* Grote

The iris borer is an example of a leaf mining caterpillar that later feeds in developing rhizomes.

Application Methods: Timing of the applications, sprays, drenches or granules is critical. Make applications in the spring, when larvae are actively feeding in leaves. 1 or 2 applications, 15 days apart, should be sufficient.

Evaluation of Results: -- Two basic methods are used, depending on the season. The first is to examine a certain number of leaves for larvae or larval feeding injury (Schuder 1958). The second is the examination of rhizomes and/or surrounding soil for injury, larvae or pupae. This involves digging up treated areas (or portions thereof) and physically inspecting rhizomes or searching the soil (Schread 1970, Dunbar 1975).

The first method is used in May or June, while the second method is used in July and August.

References

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Schread, John C. 1970. Iris borer and its control. *Conn. Agric. Exp. Sta. Res. Circ.* 235. 6 pp.

Schuder, Donald L. 1958. Promising insecticides for the control of the iris borer. *Bull. Am. Iris. Soc.* 150: 1-5.

LEAFMINERS (DIPTERA: AGROMYZIDAE)

Several species may be involved, but all have similar life histories.

For methods and other information applicable to testing insecticides against all insects on floricultural crops, see both General Considerations and the Introduction to the Floricultural Crops Section.

Obtaining Test Insects: -- If natural infestations are not available, leafminers can be reared by following procedures outlined by Webb and Smith (1970). Larvae of similar age can be obtained for testing purposes by following the procedures outlined by Smith et al. (1974).

Application Methods: -- Timing of applications will vary, depending on whether the desired objective is to prevent larval injury or kill eggs or larvae at some developmental stage. For information concerning application of sprays, aerosols, granules, etc., see the introduction to this section.

Most test methods are designed to evaluate larval mortality or injury. Two basic procedures may be used to measure efficacy. The first method is the assessment of larval mortality by dissecting larvae from leaves, or marking the limits of mines on leaves at the time of treatment and observing any further development (French et al. 1967). Smith et al. (1974) observed live and dead larvae through a binocular microscope without dissection. This method is most useful if the age structure of larval populations is similar when treated.

The second method which may be used is recording the number of mines per leaf, branch or plant (Wolfenbarger 1958). This is most useful in a field or greenhouse infestation when the age structure is not uniform, and a series of applications is made in a preventive control program.

References

French, N., Margaret Ejohn, and A. Wright. 1967. Chemical control of chrysanthemum leafminer and some observations on varietal preference. *Pl. Path.* 16: 181-6.

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Wolfenbarger, D. O. 1958. Serpentine leaf miner: Brief history and summary of a decade of control measures in south Florida. *J. Econ. Entomol.* 51: 357-9.

Fungus Gnat Larvae (Sciaridae)

For methods and statements concerning insect and mite control on all floricultural crops, see both General Considerations and introduction to the Floricultural Crops Section.

Obtaining Test Insects: -- Egg laying adults are attracted to moist soil, high in organic matter. Often plants such as broad bean (*Phaseolus vulgaris*) grown in vermiculite, attract large numbers. The area or containers used for testing should be exposed to egg-laying adults (i.e., placed in areas where adult activity is noted) for 10-14 days prior to application of treatments.

Application Methods: -- Most insecticides are applied to control larvae in the soil or roots as soil drenches. Granular insecticides scattered on the soil surface may be used. Enough liquid must be applied to ensure that the toxicant is distributed throughout the growing medium.

Recording of Efficacy Data: -- Control may be measured by recording emerged adults after application (Lindquist 1971). The soil surface is covered with a layer of white silica sand to facilitate counting of adults. Pots are covered with clear polyethylene bags or cheesecloth to trap any adults that emerge.

Another procedure is to drive larvae out of the soil with a pyrethrum drench (Lindquist, Exhibit 12). This method gives a direct larval count without having to cover treated areas, but all larvae are killed, so no subsequent counts can be made.

References

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Lindquist, R. K. 1977. Use of pyrethrins to evaluate efficacy of insecticides against fungus gnat larvae. (Exhibit 12).

Rose Midge *(Daysyneura rhodophaga)*

For methods and statements concerning insect and mite control on all floricultural crops, see both General Considerations and introduction to the Floricultural Crops section.

These pests are sometimes severe pests of field and greenhouse roses. During heavy infestations, roses are prevented from flowering due to larval feeding on terminal shoots.

Infestations often can be found in areas sheltered from wind, such as municipal parks and large estates. Greenhouse infestations also occur.

Insecticide Application: -- Applications may be made in the form of heavy sprays (e.g., a hose-end sprayer on soil setting) or granules on the soil or mulch surrounding rose bushes. Spraying plants with short-residual materials is of little benefit. Applications to soil or mulch will kill adults as they emerge (Lindquist, Exhibit 13). Make applications at 7-14 day intervals.

Evaluation of Results: -- Examination of a certain number of terminal shoots (e.g., 10) per replicate for larvae at 7-day intervals will give an

indication of control. Counts are made under a binocular microscope. Recording flowers produced also can be useful (Lindquist, Exhibit 13).

MITES

For methods and statements concerning insect and mite control on all floricultural crops, see both General Considerations and introduction to the floricultural crops section.

Tetranychids Mites

Spider mites are probably the most serious pests of greenhouse crops throughout the world (Hussey et al. 1969) largely because of their ability to develop resistance to many acaricidal materials.

Spider mites may feed on and damage some 200 host plants (Hussey et al. 1969) but the few techniques from major hosts may serve as examples of methods for nearly all hosts.

Sampling Procedures: -- Details of sampling procedures may vary with individual host plants, but most fall into one of four basic categories.

The first is the recording of mites from a certain number of leaves or flowers. Depending on the host, samples are taken at random, from leaves of similar age, or near leaves that have feeding damage (Baranowski 1966, Binns, 1969, Poe and McFadden 1972, Poe and Willret 1972).

The second sampling procedure employs the recording of mites from a certain number of leaf discs, removed at random from leaves showing any feeding injury (Taylor et al. 1969).

The third technique involves using bean seedlings as host plants. The seedlings should be trimmed of all but 2 leaves. Plants are infested by pinning infected leaves from mite colony to seedling leaves for 2-4 hours, then dipping entire plant in insecticide solutions. Living and dead mites are then recorded from the entire plant (Henneberry and Smith 1965).

The fourth technique uses a Henderson-McBurnie mite brushing machine to brush mites onto glass plates coated with a material causing mites to adhere to the surface (Schuder 1974).

In all of these procedures, some magnification is necessary to make mite counts. Generally, a binocular microscope (12-15 X) is used for this purpose.

Reporting Results : -- When mites are sampled using one of the general procedures listed above, results may be recorded in three ways:

- mean number of mites and/or eggs per leaf, leaflet, leaf disc, or groups of these;
- mean number of mites per glass plate, removed from a certain amount of foliage; or
- average infestation rating.

Sampling Interval: -- The sampling interval may vary, depending upon the objectives of the experiment, but some common intervals include 24 hours, 7 days, and 14 days posttreatment (see references under sampling procedures).

References

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Tarsonemid Mites

Broad and cyclamen mites are the two most common tarsonemid mite pests of ornamental plants. These species are usually more devastating under sheltered conditions. Because of their minute size and cryptic habits, individuals are rarely observed. Further, damage initiated in buds and unopened flowers is detected only after a latent period.

Experimental Design: -- Plants 15-20 cm tall in 10 cm diameter plastic pots are used (Hamen 1974). 4 plants are replicated 4 times and treatments applied in a randomized fashion.

Application Method: -- Two foliar applications are made at 5-day intervals as sprays with a compressed air hand sprayer at 40 psi.

Evaluation Techniques: -- Counts of live mites infesting the shoot apex are made at 1 and 13 days posttreatment. Mites are extracted in 5 ml water with detergent shaken vigorously for 10 seconds (Hamlen 1974).

References

Hamlen, R. A. 1974. The broad mite: new and important pest of greenhouse grown aphelandra. *J. Econ. Entomol.* 67: 791-792.

GARDEN SYMPHYLAN (*Scutigerella immaculata*)

Obtaining Test Species: -- Natural infestations of symphylans usually are localized, rearing populations for testing is desirable. Another system for mass rearing consists of placing 20 adults in a .947 l glass canning jar with 2.5 cm of gravel at the bottom. The remainder of the jar is loosely filled with soil at 25% soil moisture and held at 21° C, (Ramsey 1971). Ground hemlock bark at 30% moisture and 24° C as the holding temperature may be used (Berry 1972). Fresh carrot roots supplied twice weekly as food may be used (Shanks 1966). Lettuce leaves and carrot roots may be used as food (Berry 1972).

To infest plots, portions of the media containing symphylans are placed in the test area (Ramsey 1971). Several days are necessary for symphylans to become distributed within the test area.

Application Methods: -- The principal method of control are soil fumigation or preplant incorporation of pesticides (Berry and Crowell 1970). Granules are applied in the furrow or broadcast on the soil surface and incorporated. Soil drenches of liquid pesticides also can be applied at the base of individual plants. A technique of dipping roots of transplants into the pesticide solution just prior to placing in plant beds is used (Berry and Crowell 1970).

Evaluation of Results: -- Symphylan populations in experimental plot areas are recorded by examining soil from each plot (Gesell and Hower 1973). Soil examination of 25 x 25 cm root-core samples is another method of population evaluation (Berry and Crowell 1970).

Plant samples often give an excellent picture of symphylan activity. Alternate plants are removed to check for symphylan injury (Berry and Crowell 1970). Stem diameter also is measured. Plant height is recorded (Gesell and Hower 1973).

Sampling Interval: -- Evaluation for symphylan control is done at a point midway through or at the end of a crop. This ranges from several weeks to several months.

References

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SLUGS AND SNAILS

Obtaining Test Species: -- During certain seasons, animals are abundant, and can be field collected and used for laboratory trials or application of candidate molluscicides can be made during these periods of activity. However, for laboratory trials, rearing needs to be done to assure the investigator of both a steady supply of animals and a uniform population for testing. Rearing procedures are described by Arias and Corwell (1963), Brooks (1968), Cunningham and Gottfried (1967), Judge (1972) and Karlin and Naegele (1960).

Application of Candidate Molluscicides and Evaluation of Results: -- Molluscicides often are formulated as baits containing the toxicant mixed with wheat bran or apple pomace. Conventional granular or spray materials also are used, especially in preliminary trials.

Laboratory Methods: -- Most procedures involve confining animals in a container and recording mortality. Several basic methods are used.

Bait formulations are used in testing boxes (46 x 24 x 9 cm) where slugs had access to either a covered refuge or an open area containing moist soil and baits (Crowell 1967).

Slugs are directly injected with candidate materials (Henderson 1969).

Slugs are confined on filter paper or plant leaves that had been sprayed in a Potter Tower (Getzin and Cole 1964 and Wilkinson 1963).

A two-step procedure of confining slugs in containers with carrot discs dipped in solutions of candidate materials, followed by caging slugs on flats of pea seedlings sprayed with materials found promising in the first stage is used (Judge 1969).

Placing baits on greenhouse benches infested with slugs is considered to be simulated field trial (Smith and Boswell 1970).

Field Methods: -- Four basic methods may be used in field trials. These are: making spray applications of candidate materials to plants and recording the number of slugs on plants during their daily activity period (Barry 1969); placing baits beneath bait stations (usually square plywood boards), and recording dead animals daily (Howitt and Cole 1962); making applications of candidate materials and recording the feeding damage on plants (Howitt and Cole 1962); and making applications of candidate materials and recording dead animals from individual field plots (Lindquist and Krueger 1976).

References

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OUTDOOR WOODY ORNAMENTALS

The most common outdoor woody ornamentals and shrubs include arborvitae, azalea, boxwood, camelia, chamaecyparis, cotoneaster, crabapple, dogwood, euonymus, forsythia, holly, honeylocust, juniper, laurel, lilac, magnolia, oleander, palm, pine, privet, pyracantha, redbud, rhododendron, spirea, viburnum, and yew. For the purpose of pesticide test methods development, pests of woody ornamentals may be grouped as aphids, adelgids, mealybugs and soft scales, armored scales, whiteflies, lace bugs, lygus bugs and other true bugs, thrips, lepidopterous larvae, beetles, leafminers and mites. Test methods applicable to each of these groups are given under their respective headings. The following general statements are applicable to all of these groups.

Application Techniques and Equipment: -- Application techniques should be appropriate for the use contemplated and the size of the test plots used. Frequently, hand-pumped, compressed air sprayers are used in evaluating materials for efficacy on woody ornamentals. Results from such applications may be comparable to those obtained with power equipment provided that the same dilution is used and the same amount of toxicant per plant unit is applied. Commonly this is achieved by spraying to runoff (Campbell 1968). Systemic materials applied to the soil should be evenly distributed over the active root zone and this is assumed to be an area around the stem to the drip line of the tree. Dosages are calculated on a surface area basis or on stem diameter of the host (Tashiro 1973). See Nielsen (Exhibit 15) for a description and results of a method of applying a granular systemic insecticide. The systemic materials are applied to moist soil, incorporated, and watered in (Scheer and Johnson 1970, Saunders 1970). Dosages for container-grown plants are calculated as shown by Smith (1952). Other application techniques such as ULV, LV, trunk drenches, trunk injections or implantations (Brown and Eads 1977), soil injection (Brown et al. 1972) or aircraft treatments may be used when appropriate.

Plot Size: -- Generally 4 replicates are appropriate, although 3 may be used if test plants are limited and the infestation is uniform. More than 4 may be required when the infestation is sparse or uneven (Koehler 1963, Nielsen et al. 1973). To enhance validity of tests it is common practice to select test plants that are known to be infested before randomization of the plots. This may be done by taking pretreatment counts (Reinert 1973). Pretreatment counts may be used to provide guidance in establishing the experimental design (Reinert and Woodiel 1974).

Sampling: -- Evaluation of results usually involves counting the number of pests which survive the treatment and comparison of this with an untreated check and/or a standard commercial check. An indication of population reduction

by reporting percent control in relation to an untreated check is common practice (Campbell 1968). Rating schemes may be appropriate, but they must be fully explained (Campbell and Balderston 1969). Efficacy may be evaluated on the basis of plant protection, rather than on counts of living insects, when appropriate. For example, it is immaterial whether a leafminer is dead or alive if it has already destroyed the aesthetic value of the leaf in which it occurs and so it is reasonable to assess the efficacy of a pesticide on the basis of the number of leaves marred per test plant in comparison to an untreated check (Hartzell et al. 1943). The concept of an Aesthetic Injury Level in contrast to the conventional Economic Injury Level is valid.

Phytotoxicity: -- Refer to Phytotoxicity section in General Considerations.

References

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APHIDS

For methods and other information applicable to testing insecticides against aphids on outdoor woody ornamentals, see both the General Introduction and Introduction to the Outdoor Woody Ornamentals.

Colonies to be treated experimentally should be composed predominantly of apterous nymphs. The presence of substantial numbers of parasites or predators at the time of treatment may give misleading data. Some species of aphids are easily dislodged by a spray stream regardless of toxicant, expecially if a high pressure spray is used. In this case it is advisable to include a "water only" spray treatment as the untreated check to ensure validity of the resuts.

Sampling: -- Observations on effectiveness can be made 24 hours after treatment and should be repeated at 48 hours and then continued on a weekly basis at the discretion of the investigator. Counts of living aphids are usually based on plant unit (length of stem, number of leaves, etc.). These sampling units should be chosen at random from each plot and the counts should be averages of at least 3 subsamples per plot (Reinert and Woodiel 1974). Beating trays or other mechanical devices may be used for sampling plots if the above principles regarding randomization and subsampling are adhered to (Campbell 1968).

References

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Palm Aphid

Experimental Design: -- 18-month old 1.5-2.5 m tall palms are blocked according to pretreatment counts of mean numbers of aphids per leaflet. 5 replicates of one plant each are randomly treated within blocks (Reinert and Woodiel 1974).

Application Method : -- For spray materials a compressed air hand sprayer is used and thorough coverage emphasized. For drenches, 4 soil cores, 15 cm deep 10.2 cm diameter and 46 cm from the base of the palms are removed and the holes poured full of insecticide. When this material had soaked in, the entire area is flushed with water.

Evaluation Techniques: -- Total number of aphids on the 3 heaviest infested leaflets determined pretreatment and at 4, 14, and 28 days posttreatment or weekly for 4 weeks (Reinert and Woodiel 1974).

References

Reinert, J. A., and N. L. Woodiel. 1974. Palm aphid control on "Malayan Dwarf" coconut palsm. *Fla. Entomol.* 57(4): 411-413.

ADELGIDS

For methods and other information applicable to testing insecticides against adelgids, see both the General Introduction and the Introduction to the Outdoor Woody Ornamentals.

Sampling: -- On spruce, where the object of control is prevention of galls, observations on efficacy should be made after new growth has developed. At other times of the year counts of living adelgids per unit length of twig are useful supplemental data (Campbell and Balderston 1972b). On hosts where the object of control is population reduction of free-living adelgids, counts of living adelgids per plant unit (Length of twig, area of bark, etc.) are appropriate. These plant units should be chosen at random from each plot and the counts should be averages of at least 3 subsamples per plot (Campbell and Balderston 1972a).

References

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MEALYBUGS

For methods and statements concerning mealybugs, refer to the General Introduction and the section on Mealybugs in the Floricultural Crops.

SOFT SCALES

For methods and other information applicable to testing insecticides against soft scales on outdoor woody ornamentals, refer to the General Introduction and the Introduction to the Outdoor Woody Ornamentals.

Sampling: -- The stage of development of the scales when treated must be specified (Smith et al. 1971). If foliar treatments are being tested against migrating crawlers, it may be necessary to account for mechanical dislodgement. This may be done by including a "water only" treatment as the untreated check. Efficacy may be determined by counting survivors per plant unit (Koehler et al. 1965) or by determining percent mortality by examining a given number of individuals per plot (Nielsen and Johnson 1972).

Results of trials against the unarmored irregular pine scale are evaluated by taking 5 current-season twigs from each plot and determining mortality of scales on them by puncturing each with a needle under magnification; live scales exude a clear-yellowish fluid when punctured, while dead scales are either dry or exude a discolored fluid (Koehler et al. 1965).

Results are evaluated by recording the mean number of scales on 3 leaves per replicate (8 replicates), 14 weeks after treatment (Hamlen 1975).

Evaluation may be delayed to allow residues to dissipate and survivors to mature to a size which can be easily counted (Koehler 1974).

References

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Hemispherical Scale

Experimental Design: -- 15 cm diameter plastic pots of Aphelandra, in a randomized block of 4-8 replications with 1-3 plants per replicate, may be used in evaluating hemispherical scale control (Hamlen 1975a, b).

Application Method: -- Foliar application with hand sprayer at 40 psi is made, as are 1-3 drenches at 3 week intervals, with 250 ml insecticide per 15 cm container, granules are hand applied and watered in with 250 cc water.

Evaluation Techniques: -- Count of live adults pretreatment on plants may be compared with the posttreatment count. Record the number of scales appearing on previously uninfested foliage. Leaf drops may be recorded as a measure of phytotoxicity. Population counts on three leaves, basal, mid and upper portions, are made 14 weeks posttreatment (Hamlen 1975a, b).

Hamlen, R. A. 1975a. Insect growth regulator control of longtailed mealybug, hemisperhical scale and *Phenacoccus solani* on ornamental foliage plants. *J. Econ. Entomol.* 68: 223-226.

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ARMORED SCALES

For methods and general statements concerning armored scales on outdoor woody ornamentals, refer to the General Introduction and the Introduction to the Outdoor Woody Ornamentals.

Determination of individual scale mortality differs according to whether the scale species is armored or not. The relative effectiveness of treatments for the armored tea scale is evaluated on the basis of mortality of adult females at monthly or bimonthly intervals after treatment (Kouskolekas and Self 1972). Leaf samples of 3-4 infested leaves are taken from the middle and upper portion of each plant. Female scales are selected at random, the armor removed, and mortality is determined under magnification. At each sampling date two mortality counts of 100 females are made and averaged.

Experimental Design: -- 4 blocks of 10 plants each with treatments randomized on one plant replicates are used (Reinert 1974). Hedge plants are treated using 3-6 plants per treatment, with buffer between plants (Reinert 1976).

Application Method: -- Foliar sprays are applied to runoff with a compressed air hand sprayer (Reinert 1974). Granules are applied to loosened soil, then watered in. Plants are retreated after 4 weeks (Reinert 1976).

Evaluation Techniques: -- Scale populations are sampled by removing 4 leaves per plant and counting the number of live scales present. Plants are reexamined at 4, 8 and 16 weeks after treatment (Reinert 1974). One 30-40 cm long infested terminal per plant is used to determine the number of live females (Reinert 1976). After treatment counts are made at 8 and 16 weeks to determine

efficacy. Abbots formula is then used to adjust the data for control mortality (Reinert 1976).

References

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WHITEFLIES

For methods and statements concerning whiteflies on outdoor woody ornamentals, refer to the General Introduction and Whitefly section of the Floricultural Crops.

BUGS

For methods and statements concerning bugs (lace bugs, lygus bugs and others), refer to the General Introdcution and the Introduction to Outdoor Woody Ornamentals.

Sampling: -- Efficacy of materials tested against relatively inactive species may be assessed by counting all living bugs on each plant (Johnson 1960) or by counting them on randomly selected subsamples from each plant (Koehler and Rosenthal 1967). For active species which may move off plants or be easily dislodged, an injury rating system can be used (Koehler 1962).

References

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Royal Palm Bug

Because of the presence of these insects in foliage of tall established trees, special equipment is necessary to reach the sampling site. A lift of the type on service trucks of electric companies or city maintenance crews is ideal.

Experimental Design: -- Trees are 15 m tall and grouped into 5 blocks based on population size before treatment. Treatments are randomized on single tree replicates within blocks (Reinert 1975).

Application Methods: -- Sprays are applied to runoff on the entire tree canopy at 150 psi with a compressed air sprayer.

Drenches are applied by mixing insecticide in 7.6 l water in a sprinkling can and applying to loosened soil 10-15 cm deep in a circle about equal to 1/2 the radius of the drip line of each tree. A potato fork is used to loosen the soil before drenching. The application is made and followed by flooding with 38 l water.

Evaluation Technique: -- 10 infested leaflets from the most recently unfolded leaf are examined and the 3 most heavily infested leaflets are removed and brushed in a leaf brushing machine. Specimens are caught in alcohol filled petri dishes and counted at pretreatment and 4, 14 and 28 days post-treatment.

References

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THRIPS

For methods and other information applicable to testing insecticides against thrips, refer to the General Introduction and the section on thrips in the Floricultural Crops section.

Sampling: -- Efficacy is evaluated by counting the average number of thrips per leaf on 8-12 subsamples per replicate at weekly intervals after treatment (Reinert 1973).

References

Reinert, J. A. 1973. Cuban laurel thrips: systemic insecticides for control. *J. Econ. Entomol.* 66(5): 1217-1218.

LEPIDOPTEROUS LARVAE

For methods and other information applicable to testing insecticides against lepidopterous larvae on outdoor woody ornamentals, refer to the General Introduction and the section on lepidopterous larvae in the Floricultural Crops.

Cutworms

Refer to Lepidopterous Larvae in the Floricultural Crops.

Foliar Feeding Caterpillars

Refer to Lepidopterous Larvae in the Floricultural Crops.

Sampling: -- When test plants are small, it is possible to count survivors per plant (Koehler 1973). Timed-count procedures are used successfully in oakworm trials (Koehler 1975). Larvae are not removed after counting and so are available for counting at subsequent sampling intervals. Using a stopwatch, a person should record the number of live larvae seen in a 1-2 minute search of foliage on the plant. A second and third person should follow the same procedure in the same plot. Alternatively, several people can enter the same plot simultaneously with one person timing the sampling period for all. Efficacy of ovicides may be evaluated by determining percent hatch (Swenson et al. 1969).

References

Koehler, C. S. 1973. Evaluation of insecticides applied as sprays for control of the barberry looper, *Caryphista meadi*, on container grown Oregon grape, *Mahonia aquifolia*. (Exhibit 17).

Koehler, C. S. 1975. Personal Communication.

Swenson, K. G., H. Tashiro, F. L. Gambrell, and H. Breitfeld. 1969. Ovicidal efficiency of parathion and diazinon for quarantine treatment of the western tent caterpillar. *J. Econ. Entomol.*

Bud and Tip Feeders

Evaluation: -- Results of trials may be evaluated by examining entire plants for surviving insects (Pree and Saunders 1972), by examining appropriate plant units (Campbell 1968), by counting the number of adults or by a rating scheme (Koehler and Tauber 1964). Cocoons per unit weight of foliage are counted 10 months after treatment and an insect damage rating scheme is used (Koehler 1974). If plant units are used, they should be selected at random from each plot and the counts should be averages of at least 3 subsamples per plot.

References

Appleby, J. E., and R. B. Neiswander. 1966. Life history and control of the juniper tip midge. *Ohio Agric. Res. Dev. Cent. Res. Bull.* 980:26.

Campbell, R. L. 1968. Control of some pests of Scotch pine Christmas trees in Ohio. *J. Econ. Entomol.* 61(5): 1365-1369.

Koehler, C. S. 1974. Evaluation of insecticides for control of the cypress tip moth, *Argyresthia cupresella*, on *Thuja* (Arborvitae). (Exhibit 18).

Koehler, C. S., and M. Tauber. 1964. Seasonal activity and control of the Monterey pine tip moth. *J. Econ. Entomol.* 57(6): 825-829.

Pree, D. J., and J. L. Saunders. 1972. Chemical control of the European pine shoot moth. *J. Econ. Entomol.* 65(4): 1081-1085.

Bagworms

Natural infestations normally are utilized when evaluating insecticides for bagworm control. 5 larvae are tagged on each of the 4 replicate trees per treatment prior to application of insecticides (Nielsen and Balderston 1977). Trees are inspected prior to treatment to obtain an approximate larval density per 10 cm of branch tip.

Application of Insecticides: -- High volume sprays applied to runoff when larvae are actively feeding are recommended.

Evaluation of Results: -- Treatment effectiveness is measured after 1 week by counting the number of tagged larvae surviving on each tree (Nielsen and Balderston 1977). Results were evaluated by inspecting 10 branch tips, each 20 cm, per tree (Nielsen and Balderston 1976).

Nielsen, D. G., and C. P. Balderston. 1976. Juniper, bagworm control, Zanesville, Ohio, 1975. *Insect. & Acar. Tests* 1: 106-107.

Nielsen, D. G., and C. P. Balderston. 1977. Arborvitae, bagworm control, Zanesville, Ohio, 1976. *Insect. & Acar. Tests* 1: 106-107.

COLEOPTERA

For methods and statements concerning beetles on woody ornamentals, refer to the General Introduction and the Introduction to the Outdoor Woody Ornamentals.

Borers

This group of insects includes, among others, the bronze birch borer, cottonwood twig borer, apple tree borer and lilac borer.

Application Method: -- Usually entire susceptible portions of plants are treated by trunk sprays, bands, drench or granular application to the soil. Excised bolts may be treated (Neiswander 1961).

Evaluation: -- Evaluation of results may be made by counting the number of new adults which emerge from treated wood (Appleby et al. 1973), counting new attacks on susceptible plant parts (Coster et al. 1972), or by indexing schemes such as the frass indexing scheme used by Nielsen et al. (1973).

References

Appleby, J. E., R. Randell, and S. Rachesky. 1973. Chemical control of the bronze birch borer. *J. Econ. Entomol.* 66(1): 258-259.

Coster, J. E., R. G. Merrifield, and R. A. Woessner. 1972. Evaluation of four systemic insecticides against the cottonwood twig borer. *J. Econ. Entomol.* 65(2): 612-613.

Neiswander, R. S. 1961. Control of the flat headed apple tree borer. *Proc. N. Central Branch Entomol. Soc. Am.* 16: 77-79.

Nielsen, D. G., F. F. Purrington, and C. P. Balderston. 1973. Evaluation of insecticides for control of lilac borer, *Podesesia syringae* on Rancho Roundhead ash. *Pesticide News* 26(3): 58, 60.

Leaf Feeders

For methods and other information applicable to testing insecticides against the leaf-feeding adults and larvae of the beetles on outdoor woody ornamentals, see the General Introduction and Introduction to the Outdoor Woody Ornamentals.

Application Techniques and Equipment: -- Buffered cover sprays are applied with a power sprayer at 175 psi (Brown and Eads 1977). For trunk implantation of a Medicap®, an electric drill is utilized to drill the holes in the trunk. For trunk injection a hole is drilled and a hypodermic syringe is used to meter the exact amout of material for injection. The hole is then plugged with a #2 cork. All trees are thoroughly irrigated for 24 hours just prior to treatment.

Plot Size: -- A randomized block experiment is designed with 44 infested elms from 1.8 to 4.6 m tall. Untreated check and treatments consist of a single tree plot replicated 4 times.

Sampling: -- Samples from each tree consists of counting all larvae on leaves of 10 terminal twigs, 45.7 cm each, pruned randomly from the lateral periphery of the tree. Counts are made at 1, 2, 5 and 8 weeks after treatment.

Reference

Brown, L. R., and C. O. Eads. 1977. Elm leaf beetle control by spraying and trunk implantation. 1975. *Insect. & Acar. Tests* 2: 121.

Weevils

For methods and other information applicable to testing insecticides against weevils on outdoor woody ornamentals, refer to the General Introduction and the Introduction to the Outdoor Woody Ornamentals.

Location of Tests: -- The type of soil or other medium in which the plants are grown must be specified and, if container-grown, the volume of medium should be stated (Saunders 1970).

Application Techniques and Equipment: -- To control the root weevil soil fumigants may be applied under 4 ml polyethylene film (Hamlen and Beavers 1975). Plots remained covered for 7 days. The fumigants are injected 2.5 cm deep on 25.4 cm centers.

Evaluation: -- The screened cages with larvae placed in the soil are recovered 7 days after treatment and mortality recorded.

A procedure for measuring the effects of insecticides against the black vine weevil adults by conducting laboratory bioassays of spray residues applied to foliage in the field may be utilized (Nielsen Exhibit 19).

References

Hamlen, R. A., and J. B. Beavers. 1975. Evaluation of soil fumigants and soil insecticides to control *Diaprepes abbreviatus* in muck and potting soil. *Fla. St. Hort. Soc. Proc.* 88: 519-522.

Saunders, J. L. 1970. Carbofuran drench for black vine weevil control on container-grown spruce. *J. Econ. Entomol.* 63(5): 1698-1699.

Apopka Weevil

The Apopka weevil, *Diaprepes abbreviatus*, also known as the West Indian sugar cane root stalk borer weevil is a pest of field grown ornamentals in organic soils.

Experimental Design: -- Plots of soil 1.5 m x 3.0 m replicated 3 times are used to bury 8 larvae per plot at 30.5 cm depth or 6 larvae per plot at 10 cm and 60 cm depths (Hamlen and Beavers 1975).

Application Method: -- Soil fumigants are added to the soil surface under 4 ml polyethylene covered plots or injected to a 23 cm depth on 25 cm centers with a Fumigun.

Evaluation Techniques: -- Screen cages with larvae are recovered from various depths in the soil and mortality after 7 days is recorded (Hamlen and Beavers 1975).

References

Hamlen, R. A., and J. B. Beavers. 1975. Evaluation of soil fumigants and soil insecticides to control *Diapreses abbreviatus* in muck and potting soil. *Fla. St. Hort. Soc. Proc.* 88: 519-522.

LEAFMINERS

The proper interval between treatment and evaluation depends on the species involved (Matthysse and Naegele 1952), but in any case counts must be made before injured leaves drop from the plants (Hartzell et al. 1943). Species (such as some infesting conifers) which cause symptoms other than mines can be evaluated by counting the number of such sites (Tashiro 1974). Typically the proportion of damaged leaves on treated and untreated plants is compared by examining an appropriate number of leaves per plant (Kulp 1963).

References

Hartzell, A., D. L. Collins, and W. E. Blauvelt. 1943. Control of the holly leafminer. *Contrib. Boyce Thompson Inst.* 13(1): 29-34.

Kulp, L. 1963. Control of the native holly leaf miner, *Phytomyza ilicicola* (Diptera: Agromyzidae). *J. Econ. Etnomol.* 56(6): 736-739.

Matthysse, J. G., and J. A. Naegele. 1952. Control of several tree and shrub leaf miners. *J.Econ. Entomol.* 45(3): 377-383.

Tashiro, H. 1974. Biology and control of the spruce needle miner. *J. Econ. Entomol.* 67(1): 89-92.

MITES

Tetranychids, Spidermites

Several species of spidermites are known to attack ornamental plants. However, because life cycles and developmental stages are similar for the various species, test methods may be outlined according to the nature of the host plant.

On broad leaved plants (pyracantha, holly, magnolia) efficacy data are obtained from making weekly samples of the foliage. Counts are made under magnification of the number of live mites per leaf.

Four replicates of 3 plants each separated from adjacent plots by buffer plants are used in designing a test on Ilex for control of southern red mite (Poe et al 1976a, b). Granular materials are applied by sprinkling the product over the soil surface beneath the plants, sprays are applied with a compressed air hand sprayer at 40 psi. Samples consist of 10 leaves taken at random from the plants at intervals after treatment.

On narrow leaved evergreens (pine, spruce, juniper) uniform samples of twigs may be clipped and counts of live mites made on each twig (Matthyase and Naegele 1952). Mites may be extracted from foliage by using methyl isobutyl ketone (Koehler and Frankie 1968).

The effect of pesticides may be made by counting live mites and viable eggs on 3 leaflets per plant on parlor palms (Reinert 1976).

References

Koehler, C. S., and C. W. Frankie. 1968. Distribution and seasonal abundance of *Oligonychus subnudies* on Monterey pine. *Ann. Entomol. Soc. Amer.* 61(6): 1500-1506.

Matthyase, J. G., and J. A. Naegele. 1952. Spruce mite and southern red mite control experiments. *J. Econ. Entomol.* 45(3): 383-387.

Poe, S. L., H. Collisn, and Chain-ing Shih. 1976a. Effect of systemic pesticides on the southern red mite on *Ilex crenata* var. *Hetzii*. *Proc. SNA Res. Conf.* 21: 41-42.

Poe, S. L., H. Collins, and Chain-ing Shih. 1976b. Numeric response of *Oligonychus ilicis* to contact acaricides. *Proc. SNA Res. Conf.* 21: 39-40.

Reinert, J. A. 1976. Control of tumid spider mite, *Tetranychus tumidus*, on parlor palm, *Collinea elegans*, in containers. *Proc. SNA Res. Conf.* 21: 42-43.

Wilson, N. L., and A. D. Oliver. 1969. Evaluation of some acaricides for control of spidermites on three woody ornamentals in Louisiana. *J. Econ. Entomol.* 62(6): 1400-01.

Eriophyids

For species which cause galls or other distinctive plant symptoms, (rosetting, erinose, blister) rating of damage may be used as an indication of efficacy (Campbell 1969). Non gall-forming species may be counted by examining appropriate plant material with the aid of a microscope (Saunders and Barstow 1972).

References

Campbell, R. L., and C. P. Balderston. 1969. New control for maple bladder gall mite. *Pesticide News* 22(3): 78, 80.

Saunders, J. L., and D. A. Barstow. 1972. *Trisetacus campnodus* control on *Pinus sylvestris*. *J. Econ. Entomol.* 65(2): 500-501.

FOREST AND SHADE TREES

Insecticides are tested for use on forest lands either to prevent damage from, or to destroy, existing insect pest populations. Approximately one-third of the total land area of the continental United States and coastal Alaska is covered by forests. There are about 500 different species of insects that cause damage to forest trees. However, insecticides are generally developed for use only against those pests which have received attention in U. S. Forest Service Insect and Disease Regulatory Programs and by other investigators in various sections of the United States. These programs cover a wide spectrum of forestry uses and may encompass treatments of from single trees to thousands of acres in single or multiple applications. Because of the large acreages involved, and the amount of publicly owned forest lands, public agencies also conduct their own insecticide evaluation tests in the public interest. It is estimated that defoliating insects and bark beetles are responsible for 40% of all tree mortality from all destructive sources, therefore, for the purpose of test method guidelines, these are the only insect pests dealt with. Few insecticides have been developed that can be used to suppress or control large-scale outbreaks of destructive forest insects.

Experimental Design (General):--It is desirable to use the largest plot size practicable with aircraft application as soon as chemical effectiveness is proven, to reflect actual field practices and obtain operational dosage rates. Therefore, minimum plot size is generally 50 acres in a fixed-wing aircraft test, 20 acres for helicopter, and 1-3 individual trees for backpack or hydraulic sprayer studies. Corners of plots using aircraft should be marked for guidance using helium filled kytoons, groups of balloons, or other highly visible markers (Doane 1966, Doane and Dunbar 1973, USDA 1975). Study areas are usually established with the following minimum criteria:

1. An area in which insect pest population is building and which no more than one year's noticeable defoliation or damage has occurred prior to the test year, to insure that natural virus incidence is minimal.

2. A readily measurable population is present.

3. Predominance of preferred host trees suitable for population sampling (USDA 1974).

Three replications of each concentration tested are generally used with a minimum of five replicate sample stations within each plot. Foliage protection is frequently as important as population reduction as an efficacy criterion (USDA 1974).

References

Doane, C. C., 1966. Field tests with newer materials against the gypsy moth. *J. Econ. Entomol.* 59(3):618-20.

Doane, C. C. and D. M. Dunbar, 1973. Evaluation of insecticides against the gypsy moth and elm spanworm and repellant action of chlordimeform. *J. Econ. Entomol.* 66(5):1187-89.

USDA. 1974. Final environmental statement on the cooperative 1974 gypsy moth suppression and regulatory program, USDA Forest Service and Animal and Plant Health Inspection Service. March 29, 1974. Unpubl.

USDA. 1975. Pilot project work plan for 1 and 2 aerial applications of fenitrothion for control of western spruce budworm 1975. US Forest Service, Region 6, Portland, OR. Unpubl.

Gypsy Moth - *Lymantria dispar* (L.)

Experimental Design:--Generally two parameters are examined in an efficacy evaluation study: foliage protection and population reduction. Study areas with 100-900 egg masses/acre (Herbaugh et al. 1975) and a predominance of oak trees are appropriate. Infested apple orchards lend themselves well for ground application studies (Doane 1966).

Application Methods:--Experimental test plot sizes for ground application are a minimum of 0.05 acres with 5-25 acres sufficient for an aerial test; four studies are conducted on proven insecticides using triplicate plots of 150 acres or larger. More than one geographic area is desireable (USDA 1975). Application is usually made when the majority of larvae are in late 2nd instar with oak foliage 50-75% expanded.

Sampling Methods:--Foliage protection is estimated by visual examination in 20% increments before and after treatment on 1/40th acre subplots on all tree species on both test and control plots. Population reduction is estimated by measuring the percent mortality due to treatment as evidenced by pre- and post-treatment square-yard drop cloth counts (Merriam et al. 1970, USDA 1975) and pre- and post-treatment egg mass counts (Herbaugh et al. 1975). Estimates of residual population are usually measured by 24 inch terminal branch larval counts (AFRI 1972), by 5 or 10 minute timed counts on 1/10th acre (Merriam et al. 1970, Doane 1966) or on 1/40th acre subplots (USDA 1975), or by larval counts under burlap bands (Merriam et al. 1970).

Reduction of populations to less than 250 egg masses/acre generally will not require retreatment. Usually the measurement of treatment effects should be followed into the following season.

References

AFRI. 1972. Environmental impact and efficacy of Dylox used for gypsy moth control in New York State. Applied Forestry Research Institute, Syracuse, NY, Res. Rpt. No. 10. 94 pp.

Doane, C. C. 1966. Field tests with newer materials against the gypsy moth. *J. Econ. Entomol.* 59(3):617-20.

Herbaugh, L. L., W. H. McLane and C. R. Stacy. 1975. Field evaluations of insecticides against the gypsy moth, *Porthetria dispar* L. Gypsy Moth Methods Development Laboratory, Otis AFB, MA. Unpubl. 27 pp.

Merriam, W. A., G. C. Tower, E. C. Paszek and J. L. McDonough. 1970. Laboratory and field evaluation of insecticides against the gypsy moth. *J. Econ. Entomol.* 63(1):155-59.

Spruce and Western Spruce Budworm - *Choristoneura fumiferana* (clem.) and *C. occidentalis* Freeman

Experimental Design:--Study areas 20-1000 acres in size with a predominance of spruce/fir or Douglas-fir having more than 8 larvae per 100 square inches of bark surface/mid-crown branch are appropriate (USDA 1975, Schmiege et al. 1970).

Application Methods:--Treatment is generally scheduled shortly after 75% of the larvae reach 5th instar (USDA 1975) or in late 4th instar (USDA 1974). Instar identification is determined using Carolin's larval head capsule characteristics (Carolin and Coulter 1972).

Sampling Methods:--Unually 15 trees/plot in the range of 30-50 feet high are selected as sample trees. From 2-4 fifteen-inch branch samples are excised from the mid-crown region of each tree. Population density is expressed as larvae/100 new buds or shoots (USDA 1975, Honing 1968, McCowan et al. 1973). Foliage protection is usually measured by optical examination of volume of feeding on 100 buds/tree, recorded as percent defoliation to nearest 10% (USDA 1975, USDA 1974).

References

Carolin, V. M. and W. K. Coulter. 1972. Sampling populations of western spruce budworm and predicting defoliation on Douglas-fir in eastern Oregon. Pac. NW Forest and Range Experiment Station. Res. Paper No. 149. 38 pp.

Honing, F. B. 1968. Spruce budworm Zectran pilot control test-1966. USDA Forest Service, Northern Region. 12 pp. Unpubl.

McCowan, V. F. and D. A. Stark. 1973. Operational test of mexacarbate (Zectran) against spruce budworm in Main-1973. US Forest Service, Northeastern Area State and Private Forestry, Upper Darby, PA. Rept. No. P-73-5.

Schmiege, D. C., C. E. Crisp, R. L. Lyon, P. Miskus, R. B. Roberts and P. J. Shea. 1970. Evaluation Report on Zectran as a substitute of DDT in control of western spruce budworm. US Forest Service, Pac. SW Forest and Range Exp. Sta. Berkley, CA. Unnumbered Rpt. 35 pp.

USDA. 1974. Final environmental statement on cooperative spruce budworm project. Maine 1974 Activities. Northeastern Area, State and Private Forestry, Upper Darby, PA. 102 pp.

USDA. 1975. Pilot project work plan for 1 and 2 applications of fenitrothion for control of western spruce budworm-1975. US Forest Service, Region 6, Portland OR. Unpubl.

Douglas-fir Tussock Moth - *Orygia pseudosugata* McD.

Experimental Design:--Study areas 20-1000 acres in size with a predominance of Douglas-fir or true firs having 20 or more larvae and/or egg masses/1000 square inches of foliage are usually appropriate (USDA 1974, Mason 1970).

Application Methods:--Treatment is generally schedule shortly after 70% of the egg masses have hatched (USDA 1974).

Sampling Methods:--Usually 15 trees/plot in the range of 30-50 feet high are selected as sample trees. From 2-4 eighteen-inch branches are excised from the mid-crown region of each tree. Population density is expressed as larvae/1000 square inches of foliage (USDA 1974). Foliage protection is measured by optical examination of volume of feeding on 100 buds/tree expressed as percent defoliation to nearest 10% (USDA 1974).

References

Mason, R. R. 1970. Development of sampling methods for the Douglas-fir tussock moth. *Can. Entomol.* 102:836-45.

USDA. 1974. Final environmental statement, cooperative Douglas-fir tussock moth pest management plan. 562 pp. Unpubl.

Bark Beetles - *Dendroctonus frontalis* Zim., *Dendroctonus* spp.

Experimental Design:--This group of forest insect pests includes the southern pine beetle, mountain pine beetle, Douglas-fir bark beetle, etc. Test trees are generally mature, of even diameter at breast height and of the same overall height. Cut bolt sections, 15 to 18 inches long, may also be selected for test purposes (Frye and Wygant 1971). Treatments should be randomly assigned to trees or bolt sections.

Application Methods:--Insecticide formulations are applied in sufficient amounts for runoff to occur (spray to drip) using hand-held garden watering cans, compressed-air sprayers, or hydraulic spray equipment (Massey and Wygant 1954, Stevens 1959, Lyon 1965).

Sampling Methods:--Pre- and post-treatment counts are made for the numbers of bark beetle larvae, pupae, and adults per square foot in both standing infested forests and cut bolt sections (Lyon 1965, Ragenovich and Coster 1974, Buffam et al. 1973, Massey and Wygant 1954).

References

Buffam, P. E., C. K. Lister, R. E. Stevens, and R. H. Frye. 1973. Fall cacodylic acid treatments to produce lethal traps for spruce beetles. *Environ. Entomol.* 2:259-262.

Lyon, R. L. 1965. Structure and toxicity of insecticide deposits for control of bark beetles. USDA Technical Bulletin No. 1343. 59 p.

Lyon, R. L., and B. E. Wickman. 1960. Mortality of the western pine beetle and California five-spined Ips in a field trial of lindane. U.S. Forest Service Research Note PSW-166. 7 p.

Massey, C. L., and N. D. Wygant. 1954. Biology and control of the engelmann spruce beetle in Colorado. USDA Circular No. 944. 35 p.

Ragenovich, I. R., and J. E. Coster. 1974. Evaluation of same carbamate and phosphate insecticides against southern pine beetles and Ips bark beetles. *J. Econ. Entomol.* 67:763-5.

Schmid, J. M. 1972. Reduced ethylene dibromide concentrations or field oil alone kills spruce beetles. *J. Econ. Entomol.* 65:1520-1.

Stevens, R. E. 1959. Ethylene dibromide sprays for controlling bark beetles in California. U.S. Forest Service, California Forest and Experiment Station Note No. 147. 6 p.

Yasinski, F. M. 1956. Pilot test of ethylene dibromide in an oil solution for control of roundheaded pine beetle, Coconino National Forest. Forest Service Research Note RM-29. 2 p.

Exhibit 1

USE OF AEROSOL PROPELLANT TO APPLY INSECTICIDES

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This method is for the use of small universal aerosol devices to apply insecticides to run-off to small groups of plants.

The units, Universal Aerosol Kits® manufactured by ICN Pharmaceuticals, Inc., Cleveland, Ohio, are very useful in applying insecticides to small groups of plants. Insecticide solutions or suspensions are mixed in 100-150 ml lots and placed in container attached to the pressurized can by means of a plastic holder. Applications with these devices simulates spraying to run-off with a larger sprayer.

Exhibit 2

GREEN PEACH APHID CONTROL ON CHRYSANTHEMUMS

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Control of green peach aphids on greenhouse chrysanthemums with insecticides applied as foliar sprays.

Treatment	Application Rate	Mean no. aphids on indicated day after treatment[a]					
		1	2	6	14	21	27
A	0.25 gm	0	0	0	0	0	0.2
A	1.0 gm	0	0	0	1.0	1.2	0
B	0.25 gm	0.5	0	0	0	0	0
B	1.0 gm	0.2	0.5	0	0	0	0
Check	-	18.2	18	20	20	24	26

[a]Means of 4 replications; 2 plants/replicate; aphids recorded from upper surface of 4 apical leaves/replicate.

Cultivar: 'Bright Golden Anne'

Stage of Growth: Vegetative, 4 wk after potting.

Application Equipment: 7.8 liter compressed air sprayer.

Temperature: Generally 23-24°C day, 16-16°C night.

Phytotoxicity: None noted in this test.

Remarks: Both materials are effective in controlling green peach aphids at rates used.

Exhibit 3

CHRYSANTHEMUM TESTS
GREEN PEACH APHID CONTROL

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CROP: Greenhouse chrysanthemums (pot): Cvs. "Orange Bowl", "Mermaid", "Neptune", "Vermilion", "Ice Follies".

STAGE: Nearly full bloom

PEST: Green peach aphid, *Myzus persicae*

METHODS: Chemicals were applied as soil drenches onto 21.2 cm diam. pots, each pot containing 5 plants of one variety. Each treatment was applied onto 1 pot of each variety.

TREATMENT DATE: April 21, 1972

TEMPERATURE: 21-23°C

Treatments Applied April 21, 1972	Pretreatment Count		May 7, 1972	
	No. of blooms with live aphids	with no live aphids	No. of blooms with live aphids	with no live aphids
Check	49	0	49	0
A	73	0	10	63
B	69	0	34	35

Phytotoxicity

None, blooms are open on all varieties

Exhibit 4

GREEN PEACH APHID CONTROL ON CHRYSANTHEMUMS

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Materials and Methods

The experimental design to test the efficacy of four systemic insecticides to control aphids on chrysanthemums include a control and insecticide treatments of A, B, C and D at dosages of approximately 1/2X, 1X and 3X recommended rates applied to the following ten chrysanthemum varieties:

1 - Mefo
2 - Southern Comfort
3 - Fred Shoesmith
4 - Albatross
5 - Southern Sun
6 - Indianapolis
7 - Princess Anne
8 - Iceberg
9 - May Shoesmith
10 - Detroit News

The design is replicated four times.

Five cm rooted cuttings of these varieties are used. The rooted cuttings are planted in 12.7 cm pots containing the Cornell Peat-lite mix. The plants are maintained on a constant feed program of 20-20-20 fertilizer and grown at 21°C day - 15°C night temperatures. They are brought to flower under standard commercial practices. One week after potting ten green peach aphids are placed on each plant from cultures maintained at the insectary. Three weeks after potting insecticides are applied to the soil at the following rates:

Formulation	Dosage of formulated material (recommended rate)		
	1/2X	1X	3X
15% granular	.5 gm	1 gm	3 gm
19% granular	.5 gm	1 gm	3 gm
10% granular	.5 gm	1 gm	3 gm
R LC	.5 gm	1 gm	3 gm

The same applications are repeated 8 weeks after planting, so that the insecticide treatment consists of two applications during the production of the crop.

Twelve weeks after potting, when flowers are in full bloom, the number of aphids on the top leaf of each plant are counted. The height of the plant is measured and the level of phytotoxicity is evaluated on a scale of 0-5 (0 = none, 5 = total). Analysis of variance of these data are computed using the analysis of variance, program for factorial design developed by the Computer Activities Group at Cornell.

Results and Discussion

Three dependent variables: (1) the number of aphids per top-leaf, (2) the relative level of visible phytotoxicity, and (3) plant height, are observed as measures of insecticide efficacy in this experiment. A three-level factorial design including insecticide treatment, dosage and plant variety is used for the analysis of variance for each of the dependent variables.

Aphid Control:--Although there are significant differences in the number of aphids per top-leaf at all three levels, the differences between insecticide treatment means ($F = 74$) are much greater than those between dosages ($F = 4$) and varieties ($F = 5$). When all dosages are considered, the number of aphids per top-leaf is lowest in the 10G treatment in all varieties ($\bar{x}$ 8).

GRANULAR SYSTEMIC INSECTICIDES FOR GREEN PEACH APHID CONTROL ON CHRYSANTHEMUMS

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Regular and latered release formulations for green peach aphid control on pot- grown chrysanthemums.

Treatment[a]	Rate (gm/pot)	Mean no. aphids/plant at indicated interval pre- and posttreatment[b]						
		Pretreat	24 hr	72 hr	7 day	14 day	21 day	28 day
Regular	0.1	62.8	29.5	0	0	0	0	2.5
Regular	0.05	65.5	55	3.5	0	.2	0	10.5
Altered release	0.1	105.2	125	22.2	0	0	0	19.2
Altered release	0.05	68	325	4.0	0	0	0	14.8
Untreated	-	86.5	127.2	153.2	281.2	340.2	490.2	1020.5

[a] Applied 10/22/74; all treatments applied to soil surface; cv. "Bright Golden Anne"; plants approximately 6 wk old.

[b] Means of 4 replicates; aphids recorded from 1 plant/rep.

Temperatures were variable, depending on sky cover. Generally, the range was 21-22°C day, 18-19°C night.

No phytotoxicity noted.

Exhibit 6

THE EFFECTIVENESS OF VARIOUS INSECTICIDES FOR THE CONTROL OF THE GREENHOUSE WHITEFLY ON GERBERA - San Jose, 1972

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The tabular data illustrate the use of pre-treatment counts in establishing the presence of a infestation, suitable sampling methods and sampling intervals.

Material	Lbs. act. per 100 gals.[1]	Pre-Treatment count	Post treatment count after:[2] 12 days	20 days	27 days
A	0.5	9,080	93 a	992 a	64
B	0.5	11,152	1,719 b	957 a	2,212
C	0.5	7,228	6,007 c	4,488 ab	3,254
D	1.0	12,896	9,232 c	1,730 a	683
E	0.5	11,604	21,527 c	-	-
F	0.5	10,748	10,956 c	-	-
G	0.5	10,424	11,439 c	-	-
H	0.5	12,732	12,102 c	-	-
I	0.5	11,954	20,004 c	-	-
Check	-	11,430	11,532 c	7,443 b	6,037

[1] Full coverage sprays applied on March 31.

[2] The number of whiteflies found on 5 leaf punches 4 cm in diameter. Counts followed by the same letter are not significantly different at the 5% level.

No injury was evident from any of the treatments.

Exhibit 7

WHITEFLY CONTROL ON POINSETTIAS

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Poinsettias are grown in 10.2 cm diam. pots.

Granules are broadcast on foliage of closely-spaced plants with a shaker jar; granules are applied to foliage from pre-weighed dosages in glass vials.

Temperatures during the experiment varied but are generally 21-22°C day and 18-20°C night.

No phytotoxicity was observed throughout the trial.

Treatment[a]	Cultivar[b]	Mean no. nymphs on indicated day posttreatment[c]				
		14	21	37	83	104
Soil (Broadcast)	White	75.8	10	0.2	0.2	26.5
	Red	216.0	7.2	0	1	17
Wet Foliage (Broadcast)	White	166.5	14.5	4.8	0.5	34.5
	Red	159.8	8	4.2	4.8	24.0
Dry Foliage (Broadcast)	White	329.0	26.2	0.5	0	3.0
	Red	143.0	24.2	0.8	2.2	18.2
Untreated	White	460.2	45.5	76.8	70.5	52.5
	Red	206.5	39.8	30.2	50.2	18.5

[a] Applied 10/30/73; foliar treatments applied at rate of 4 oz. formulation/100 ft^2; soil treatment applied at rate of 0.1 gm formulation/10.2 cm diam. (= 4-in.).

[b] White = "Ekkespoint C-1 White"; Red = "Dark Red Hegg"

[c] Means of 8 replications; whitefly nymphs recorded from 2 subapical leaves/rep.

EVALUATING INSECTICIDES FOR GREENHOUSE WHITEFLY CONTROL ON POINSETTIA

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Lafayette, Indiana

Similarly infested 15.2 cm tall (6-in.) plants are selected, and each treatment applied to 4 plants (1 plant = 1 replicate). Leaves for future sampling of immature stages are marked with white tags. Temperature at application was 28°C (80°F). Application is made with B & G sprayers operating at 30 psi. Counts of the number of live nymphs and empty "puparia" are made 7 and 14 days post treatment. No mention was made of the number of leaves or leaf sections sampled. This should be made clear in the future use of this or similar method.

Results of Whitefly Experiment

Material	Gals. Water	Counting Dates: T Live	T Emerged	T + 7 Live	T + 7 Emerged	T + 14 Live	T + 14 Emerged
A	3/4 lb	--	--	71.5a	25 a	157.3a	4.8
B	Aerosol	--	--	124 a	10 a	151.3a	3.3
C	1 qt.	--	--	145.2a	31 a	178.5a	20.5
D	Aerosol	--	--	158.8a	70.3b	190.9a	64.8
E	75%	--	--	193.5a	7.3a	217.5a	5.0
F	2 qts.	--	--	226.5b	20.5a	203.5a	10.8
G	Aerosol	--	--	470.8b	84.3b	345.3b	41.0
Check	Untreated	162.3	71.2	220 a	75.8b	196.7a	45.0
L.R.S.D. 5%		--	--	132.5	47.7	110	NS
L.R.S.D. 1%		--	--	216.6	--	180	NS

Exhibit 9

FLOWER THRIPS EXTRACTION

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Extracting thrips or aphids out of the flower or plant samples is accomplished with Berlese funnels. With this technique, the samples are collected in alcohol and labelled so that if time does not permit an immediate count, the count can be made later.

Exhibit 10

FLOWER THRIP EXPERIMENT

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An established bed of carnations is divided into 1 m^2 plots and an experiment laid out with 4 replications on April 12, 1974 at the Indiana State Soldier's Home greenhouse. At the time of application it was bright and sunny, the temperature was 35°C (96°F) and the relative humidity was 64%. Sprays are applied with a 3.8 liter B and G sprayer and, granulaes are applied with a Vibra-seeder passed between the rows of carnation plants and watered immediately. Aerosols are applied for 45 seconds approximately .5 m from the plants.

Carnation flowers from each plot are removed, placed in paper sacks and transported to the laboratory where the flowers are split open and placed in Berlese Funnels for 24 hours. The thrips driven from the blossoms are caught in vials containing 70% alcohol and then counted in a watch glass under a binocular, dissecting microscope. Samples are taken at the time of treatment (T) and at T + 1, T + 4, T + 7, T + 10 (time of second treatment 4/22/74) and samples are taken at 2T + 7 and 2T + 10.

A and C caused some blanching of buds.

The results of the experiment are shown in the following table:

1974

FLOWER TRIPS, *Frankliniella tritici* FITCH ON CARNATIONS

INDIANA STATE SOLDIER'S HOME

Formulation Treatment	Average No. thrips/flower Sample Dates							
	T	T + 1	T + 4	T + 7	T + 10	2T + 4	2T + 7	2T + 10
A	-	33.6	2.3	1.5	4	2.8	5.3	4.8
B	-	8.5	3.0	23.3	3.3	11	17.8	12
C	-	27.5	0	2	11	8.3	6	12.8
D	-	31	7.5	1.8	3.8	5	5.3	10.8
E	-	31	4.3	2	2.3	19.3	5.8	20.3
F	-	22	8.5	2.5	2.5	7	11	12.5
G	-	15.3	11	9	6	32.3	10.8	9.8
H	-	37	8	7.3	24.5	53.8	1	21.5
Check	61.3	36	15	14.5	19.5	38.3	16	28.3
LRSD		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Exhibit 11

THE EFFECTIVENESS OF VARIOUS PESTICIDES APPLIED AS SPRAYS FOR CONTROL OF THE OMNIVOROUS LEAF ROLLER ON GREENHOUSE ROSES. SAN BRUNO, CALIF. 1967

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Material[1/]	Pounds Actual per 100 gallons	No. of larvae found 14 days after treatment[2/]
A E. C.	1.0	0
A W. P.	1.0	2
B E. C.	0.75	2
B W. P.	0.75	3
c E. C.	0.5	2
D W. P.	1.5	6
E W. P.	1.0	19
F W. P.	1.0	22
G E. C.	1.0	29
Check		51

1/ Materials applied on September 11 at 1900 G.P.A.

2/ Count based on the number of larvae found during 100 minutes search of 40 feet of bed.

Exhibit 12

USE OF PYRETHRINS TO EVALUATE EFFICACY OF INSECTICIDES AGAINST FUNGUS GNAT LARVAE

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OARDC
Wooster, Ohio

Control of fungus gnat larvae on bedding plants with several insecticides applied as soil drenches

Treatment[1]	Rate	Mean no. larvae 5 days posttreatment[2]
A	4 oz	.5
A	8 oz	1
A	16 oz	0
B	4 oz	2.5
B	8 oz	5.5
C	16 oz	4.8
Untreated	-	12

1/Treatments applied with a watering can to plants growing in flats.

2/Means of 4 replications. Larvae recorded on soil surface after drenching with synergized pyrethrins (1 capful/gallon water) to drive them to surface.

Exhibit 13

CONTROL OF ROSE MIDGE LARVAE WITH INSECTICIDES:
COLUMBUS, OHIO, 1975

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Wooster, Ohio

Treatment[1]	Rate	Mean no. rose midge larvae on indicated date[2] 6/25	7/2	7/11	7/17
A 2 G	5 lb/1000 ft^2	4 a	4 a	2.3 a	1.5 a
A	12 oz/100 gals.	2.3 a	0.5 a	0.2 a	3.3 a
B	1 fl. oz/gal.	39.3 ab	7.5 a	2.7 a	14 a
C	32 oz/100 gals	96.8 b	103.7 ab	30 b	64.7 b
Untreated	--	195.8 c	92.7 ab	86.7 c	85.3 b

1/ Treatments applied 6/16, 6/23 (except A 2 G), 7/2, 7/17; application made with Ortho Hozon sprayer on soil setting; A 2 G applied with fertilizer spreader.

2/ Means of 3 replicates; 10 terminals sampled/replicate; mean in each column followed by same letter not significantly different at .05 probability level.

Exhibit 14

TESTS ON CARNATIONS FOR THE CONTROL OF THE TWO SPOTTED SPIDER MITE, *Tetranychus urticae* (Koch)

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An established bed of carnations is divided into .8 m^2 (9 ft^2) and an experiment laid out with 4 replications on April 12, 1974. At application time the temperature was 35°C (96°F) and the weather bright and sunny and the relative humidity 64%. Sprays are applied with a 3.8 liter B & G compressed air sprayer. Granules are applied by passing a Vibro-Seeder between the rows of carnation plants, plants were watered immediately. Aerosols are applied for 45 seconds per plot at approximately 46 cm (18 in.) from the plant.

A 30 cm (12 in.) sample of carnation stem and leaves is removed, placed in a paper bag and transported to the laboratory where the samples are brushed from the plants with a Henderson-McBurnie mite brushing machine. Mites removed from the plant are collected on 12 cm round glass plates. The mites are counted beneath a binocular, dissecting microscope.

A and C caused some blanching of buds.

Samples are taken at time of treatment (T) and at T + 1, T + 7, (time of 2T 4/22/74) 2T + 7, 2T + 14.

The results of this experiment are shown in the following table:

Formulation Treatment	Average no. mites sample dates				
	T	T + 1	T + 7	2T + 7	2T + 14
A	-	.8	1.8	4	7.5
B	-	1.0	2.8	9.3	38.0
A	-	1.8	6.3	4.5	13.0
A	-	2.0	4.0	3	7.7
A	-	2.5	3.0	9.3	6.7
C	-	1.0	1.5	8	4.8
D	-	1.8	1.0	0	.3
E	-	.3	.5	13	21
F	-	8	7.5	27.8	25
Check - Untreated	4.3	8	10.5	11	17.5
LRSD 5%	-	5.4	5.4	9.7	13.5
LRSD 1%	-	-	-	13.1	18.2

Examination of these data indicate that all of the treatments except F reduced the population of the two spotted spider mite significantly in the first experiment. The second treatment did not result in a dramatic reduction of the numbers of mites. D was the outstanding material for control of the two-spotted mite on carnations. Of the series of A treatments applied, the granular formulation seemed to perform the best and gave the longest period of effectiveness.

Exhibit 15

EVALUATION OF GRANULAR, SOIL-APPLIED SYSTEMIC INSECTICIDES FOR CONTROL OF INSECTS ON SHADE TREES IN NURSERIES

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Wooster, Ohio

Procedure

Cultivate 2-foot wide band of soil from tree trunk toward middle of row to depth of 3-4".

Apply granular insecticides with Gandy Turf Tender, Model 24H (=2' wide) or equivalent, to one or both sides of trees.

Cultivate again as above.

Apply overhead irrigation immediately (ca. 1" of water). Repeat irrigation at weekly intervals unless rainfall totals 1"/week. Monitor sucking insect populations at 2 week intervals with D-Vac or equivalent suction device.

Quantify defoliator or bark beetle activity by counting number of caterpillars or new exit holes/unit area when larvae are present.

Insecticide	Rate	Total Nymphs Sample Date 6/18	7/7	7/20	8/3	8/19	9/16	Σ
A	10 lb AIA (1 side)	28	8	13	22	3	0	74
A	5 lb AIA (2 sides)	3	18	26	31	1	0	79
A	1 oz (1 side)	1	2	5	3	0	0	11
A	1 oz. (2 sides)	0	0	19	6	0	0	25
A	2 oz. (1 side)	0	0	3	0	2	0	5
A	2 oz. (2 sides)	0	0	0	2	1	0	3
B	20 lb AIA (1 side)	18	14	9	5	3	0	49
B	10 lb AIA (2 sides)	16	15	9	21	1	0	62
B	4 oz. (1 side)	2	5	4	5	0	0	16
B	4 oz. (2 sides)	0	6	9	5	0	0	20
Check		15	6	23	26	1	0	71

Application Date: May 12, 1976

Application Equipment: Gandy 2' wide granule spreader

Location: Clark Co., Ohio

Exhibit 15 continued

Exhibit 16

EVALUATION[1/] OF INSECTICIDES AND SPRAYING SCHEDULES FOR CONTROL OF KUNO SCALE, *Lecanium kunoensis*, ON PYRACANTHA, Walnut Creek, Calif. 1973-74

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Material	Act. tox., lbs. per 100 gal.	Date(s) of application[2/] in 1973	Avg. no. scales/inch of twig growth[3/]	% scale reduction[3/]
A (75 SP)	1.0	June 16	2.23	32
A (75 SP)	1.0	June 16, July 5	0.65	80
B (3 EC)	0.5	June 16	0.97	70
B (3 EC)	1.0	June 16	0.82	75
C (80 Spr.)	1.0	June 16	1.33	59
C (80 Spr.)	1.0	June 16, July 5	0.45	86
Untreated	-	-	3.28	-

1/ Single plant plots sprayed to point of complete coverage using hand compression sprayer. Four replications.

2/ Peak of crawler emergence in 1973 occurred approximately June 1.

3/ Evaluation made May 27, 1974; surviving females counted on 5 twig samples, each approximately 11 inches long, collected from each plot.

Exhibit 17

EVALUATION OF INSECTICIDES APPLIED AS SPRAYS FOR CONTROL OF THE BARBERRY LOOPER, *Coryphista meadi*, ON CONTAINER GROWN OREGON GRAPE, *Mahonia aquifolia*, Saratoga, Calif. 1973

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Material[1]	lb./100 gal.	No. living larvae/6 plants after (days):[2] 5	12	26
A	1.0	0	0	1
B	.5	0	0	2
C	1.0	0	0	1
D	.5	0	1	0
E	[3]	1	13	4
F	[4]	12	21	8
G	.5	0	1	2
H	.5	0	10	6
Untreated	-	130	71	14

[1] Applied to single plant (12-24" high) plots, replicated 6 times, on June 7 Full coverage sprays applied using hand compression sprayers. No phytotoxicity noted from any treatment.

[2] All living larvae on each plant counted at intervals noted.

[3] 2 lb. wettable powder formulation, containing 4,320 I.U./Ng used/100 gal. water.

[4] 0.5 lb. wettable powder formulation, containing 6,000 A.U.Ak./Mg, used/ 100 gal. water.

Exhibit 18

EVALUATION OF INSECTICIDES FOR CONTROL OF THE CYPRESS TIP MOTH, *Argyresthia cupressella*, ON *Thuja* (ARBORVITAE), Berkeley Calif. 1973-74

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Treatment[1]	Act. toxicant, lb./100 gal.	Avg. no. cocoons/ 10 grams foliage[2]	Unsightliness rating[3]
A (3 EC)	0.5	0.32	1.5
A (3 EC)	1.0	0.30	1.3
B (75 EC)	1.0	0.43	1.3
C (4,320 IU/Mg)	2.0	10.53	3.8
D (2 EC)	0.5	0.37	1.5
E (4 EC)	0.5	1.57	2.0
Untreated	-	14.95	3.8

1/ Treatments applied May 16, 1973, when adult moths are active. Full coverage sprays applied by hand compression sprayer to single plant (4-6' tall) plots replicated 4 times. No evidence of phytotoxicity noted from any treatment.

2/ Cocoon counts made Mar. 15, 1974 after taking 4, 4" terminal samples of foliage from each plot. Foliage samples weighed to standardize foliage volume.

3/ 1 = no unsightliness attributable to tip moth, to 4, representing severe browning of plants. Rating of 2.0 or over considered unacceptable.

Exhibit 19

METHOD FOR USING LABORATORY BIOASSAYS OF SPRAY RESIDUES APPLIED TO FOLIAGE IN THE FIELD FOR BLACK VINE WEEVIL ADULT CONTROL

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Taxus media Rehder cv. Vermeulen and *T. media* cv. Hatfield, over 3 m high, located in the Secrest Arboretum at the Ohio Agricultural Research and Development Center are used. The south sides of the plants are sprayed to run-off with a compression sprayer on August 3, 1976. Ambient temperature was 24°C. At regular intervals, 10-15 cm twigs are clipped, taken to the laboratory, and placed in 9 x 16 cm (1 qt) cylindrical paper cartons fitted with screen lids. Five ovipositing weevils are added to each carton. These are collected from untreated *Taxus* in nurseries and held at least 7 days on *Taxus* foliage. Preconditioning and testing conditions are 20°C and 90-95% RH with 15 h light/day. Treatments, including water-sprayed checks, are replicated 3 times. Initial readings are made 24 h after confinement at which time it was impossible to distinguish dead from moribund individuals, especially those intoxicated with pyrethroids. Consequently, weevils are held for 4 additional days with either treated or untreated foliage. In both bases, fresh-cut foliage replaced older foliage on alternate days. This method duplicates field circumstances, i.e., adults crawling onto treated foliage to feed, walking or falling off in response to the toxicant, and either returning to the treated plant or moving to an untreated area.

Table 1. Percent black vine weevil adults moribund 24 h after confinement with Taxus foliage, sprayed until runoff Aug. 3, 1976.

Insecticide	g AI/ 100 liter[a/]	1 hour	1 day	3 days	1 week	2 weeks	3 weeks	4 weeks	6 weeks	8 weeks
A 2EC	30(0.25)	100	100	100	100	87	100	80	33	0
B 2.4EC	15(0.125)	100	100	93	100	100	100	100	54	47
B 2.4EC	30(0.25)	100	100	100	100	100	100	100	100	100
C 76WP	60(0.5)	100	100	93	33	13	-	-	-	-
C 76WP	120(1.0)	100	100	100	27	27	0	-	-	-
D 75SP	60(0.5)	100	100	7	0	-	-	-	-	-
D 75 SP	120(1.0)	100	100	70	13	27	7	-	-	-
E 2EC	120(1.0)	100	100	0	-	-	-	-	-	-
F 80S	60(1.0)	0	-	-	-	-	-	-	-	-
Check		0	0	0	7	0	7	0	0	0

a/ Rates in parentheses are lb AI/100 gal.

Exhibit 19
continued

*U.S. GOVERNMENT PRINTING OFFICE: 1978 260-880/24 1-3