Citrus Pest Insecticides

screened by laboratory and field tests as new control chemicals are developed

R. L. Metcalf, R. B. Carlson and U. E. Murphy

Applying adult greenhouse thrips to treated fruit.

New synthetic organic insecticides for controlling citrus insects and mites require proving upon the individual species because of the remarkable degree of specificity shown by the compounds.

An example of this specificity of insecticidal action is found in DDT, which is ineffective against the German cockroach and the Mexican beetle but very toxic to their close relatives, the American cockroach and the various lady bird beetles.

The Citrus Experiment Station at Riverside has conducted screening tests of new materials for several years, with the threefold objective of:

1. Measuring the performance of known insecticides against citrus pests;

2. Discovering new insecticidal compounds; and

3. Obtaining fundamental information on the relation of insecticidal action to chemical structure and properties.

Insects and mites which are important citrus pests and yet which can be reared readily or obtained from natural infestations in large numbers on a year-round basis are used in developing this program.

Test methods conform as closely as possible to conditions encountered in field practice.

Insects and Mites Tested

The test insects which were chosen for major emphasis were the adult female and crawler stages of the California red scale, *Aonidiella aurantii;* the egg and adult female stages of the citrus red mite, *Paratetranychus citri;* the adult female greenhouse thrips, *Heliothrips haemorrhoidalis,* and the immature stages of the green citrus aphid, *Aphis spiraecola.*

In a year's investigation, about 16,000 grapefruit and 15,000 oranges are treated with test insecticides and about 1,000,000 red scale and 1,000,000 red mite eggs are examined for mortality under the microscope. In addition, nearly 200,000 greenhouse thrips and 200,000 adult citrus red mites are individually placed on treated fruits and are checked for mortality.

The compounds for tests with citrus red mite and greenhouse thrips adults are made up as standard weight per volume solutions in 100 milliliters of acetone. Mature Valencia oranges are dipped in this solution for one second and allowed to dry. Approximately 0.25 ml. of solution remains on the fruit which dries almost instantly, leaving a residual deposit of insecticide.

Each treated fruit is then infested with about 25 insects or mites from stock colonies.

Mortality counts are made in 24 hours and again in 48 hours if the material is slow acting.

Nearly all of the thrips that are alive remain on the fruit, while those that have been killed fall to the bottom of the individual containers, affording an easy and accurate method of counting. If a high mortality count is obtained with the 1% solution, it is diluted successively to 0.5%, 0.25%, 0.1%, 0.05%, etc., until the material no longer kills. The values obtained then may be plotted in a mortality curve and the median lethal concentration determined.

Red Scale and Mite Eggs

In the testing of materials against California red scale and citrus red mite eggs, a different method is employed. The compound is emulsified or suspended in water containing 0.03% blood albumin spreader. Solid compounds are formed into very fine suspensions by adding saturated acetone solutions to water. The resulting emulsion or suspension is sprayed directly upon infested grapefruit mounted upon a turntable, each fruit being sprayed for two revolutions on each axis.

The red scale adults are used when they are 36 to 40 days old and of uniform susceptibility. They are held after spraying for 21 days when the adult female scale are counted under the binocular microscope for per cent mortality.

The effect of the residue of the compound on the immature crawler stage of the scale which emerges from the adult female at 40 to 42 days is determined by counting the number of live second instar scale settled per adult female. Grapefruit containing citrus red mite eggs three days old are sprayed in the same manner and are counted to determine the per cent hatching in seven days.

Dipping fruit in acetone solution to apply residual coating of test material.

In both of these tests the compound is sprayed at a high concentration of 1% or 0.5%, initially, and if more than 50% kill is obtained, the concentration is decreased to 0.25%, 0.1%, 0.05%, etc., until no kill results. From the values obtained, dosage mortality curves are readily plotted and the median lethal concentrations are calculated.

Greenhouse Thrips

The chlorinated hydrocarbons DDT, benzene hexachloride, chlordan, and chlorinated camphene, are highly toxic to the greenhouse thrips but almost nontoxic to the citrus red mite. Their use in actual field practice usually has resulted in alarming increases in citrus red mite populations.

In contrast, the organic phosphates, tetraethyl pyrophosphate and parathion are very highly toxic to both the thrips and the mites. The new miticides, bis-(p-chlorophenoxy)-methane and 1, 1-bis-(p-chlorophenyl)-ethanol are ineffective to the thrips but are highly effective to the citrus red mite.

Many parallel tests of these various toxicants are undergoing study to determine the effectiveness of various chemical groupings and to correlate molecular structure with insecticidal action. More than 150 relatives of DDT, about 100 compounds related to parathion, and

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more than 200 related to chlordan have been investigated.

Preliminary Studies

In preliminary laboratory studies, some of these compounds have proven more effective than their parent materials and may be insecticides of the future.

The laboratory investigations are only the beginning steps in the proving of a new insecticide. If a material proves highly effective in the screening tests, a larger sample is procured. This is then given preliminary field studies to determine its effectiveness under field conditions, its toxicity to citrus trees, and its effects on beneficial insect populations.

If these tests still indicate promise, the material is carefully considered from the standpoint of toxicity to warm-blooded animals, most suitable formulations and methods of application, duration of residual effectiveness as determined by chemical and biological assays and finally cost of application.

Of approximately 2,400 compounds studied to date—exclusive of those studied as fumigants—only about 70, or less than 3% have proven promising enough to be investigated in the field, and of these 70, less than 20 will eventually show enough promise to warrant extensive field studies.

Comparative Toxicities of Some New Organic Insecticides to the Citrus Red Mite and the Greenhouse Thrips

Material	Per cent concentration for 50% kill	
	Citrus Red Mite	Greenhouse Thrips
2,2-bis-(p-chlorophenyl)-1,1,1-trichloroethane (DDT)	>10.0	0.001
gamma-benzene hexachloride	1.0	0.0001
chlordan	1.0	0.0035
toxaphene	>1.0	0.0025
2,2-bis-(p-chlorophenyl)-1,1-dichloroethane (DDD)	>1.0	0.006
2,2-bis-(p-methoxyphenyl)-1,1,1-trichloroethane (methoxychlor)	>1.0	0.03
bis-(p-chlorophenoxy)-methane (Neotran)	0.025	1.0
1,1-bis-(p-chlorophenyl)-ethanol (DMC)	0.1	1.0
tetraethyl pyrophosphate	0.0005	0.0003
parathion	0.0001	0.0001

Comparative Toxicities of Some New Organic Insecticides to California Red Scale and Citrus Red Mite Eggs

Material	Per cent concentration for 50% kill	
	Red Scale	Red Mite Eggs
parathion	0.01	0.009
tetraethyl pyrophosphate	0.1	0.7
lorol-2-thiazolinyl sulfide (IN-4200)	0.1	0.02
di-(2-ethylhexyl)-phthalate	0.25	0.1
DDT	nontoxic	nontoxic
gamma-benzene hexachloride	nontoxic	nontoxic

R. L. Metcalf is Assistant Entomologist in the Experiment Station, Riverside.

R. B. Carlson is Laboratory Technician, Citrus Experiment Station, Riverside.

U. E. Murphy is Laboratory Technician, Citrus Experiment Station, Riverside.

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FRUIT SET

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Although the information is limited, there is some indication that treated fruits soften quicker after reaching full maturity than do those that have set by normal pollination.

Varieties

In tests in California, hormones have set fruit on several strains of Earliana, on Pearson, Pritchard, Stokesdale, Stone and Pennheart.

These results, and information from other states, indicate that the treatment will set fruit on most varieties providing conditions are favorable. However, from the standpoint of quality, the treatment may not prove satisfactory on those varieties that tend to be rough, puffy, or have blossom-end rot.

Sunburning of the fruit may be a factor on varieties that have sparse foliage.

Early Market Crops

Hormone treatment is most likely to prove useful for increasing early harvest on crops grown for the spring and early summer market.

Hormones have improved fruit set and increased early yields in one or more tests in each of the early market districts of the state. On the other hand, in some tests the treatments proved unsuccessful because good set was occurring naturally, while in others poor set was due to causes which apparently cannot be corrected by the treatment.

Due to variations in climatic conditions, results are likely to vary from year to year as well as among districts.

Since it is difficult to predict results, commercial tomato growers are advised to proceed cautiously with the use of hormones. Extensive use of the material should not be attempted until the grower has determined to his own satisfaction that the treatment will prove beneficial under his growing and marketing conditions.

Late Market Crops

Poor fruit set is seldom a problem on tomatoes grown for late summer and fall marketing.

The few tests conducted on these crops have shown the treatment was of little or no value. Even when fruit set has been increased late in the fall, cold weather or frosts terminated harvesting before the treated fruit matured.

Canning Tomatoes

Hormone treatment, at the present time, is not recommended for the canning tomato crop.

In the first place, only occasionally is delayed fruit set a serious problem on most of the acreage, and this is difficult to predict early in the season.

Earliness is not usually as important on this crop as it is with market tomatoes because the price of the crop is more stable. Therefore, the failure of the first few flowers to set is seldom considered serious. However, in those areas where fruit set is poor over prolonged periods, hormone treatment should be tested further.

Care Required

Another disadvantage is the danger of reducing total yields. While this may be avoided by careful application of the spray, most growers agree that hand spraying of tomato fields grown for canning is impractical. With 4-CPA—4-chlorophenoxyacetic acid—whole plant spraying usually causes too much plant damage and at the same time is not as effective in setting fruit as cluster spraying.

If materials or methods of application less injurious to the plant are discovered, treatment of the canning crop may become feasible.

P. A. Minges is Associate Agriculturist, Truck Crops, in Agricultural Extension, Davis.

L. K. Mann is Assistant Professor of Truck Crops and Assistant Olericulturist in the Experiment Station, Davis.

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Local experience on the results of hormone treatment can be obtained from the Farm Advisors' offices. Staff members of those offices coöperated in the studies reported here.