Systemic Insecticides

control of plant feeding pests by poisoning plant juices studied

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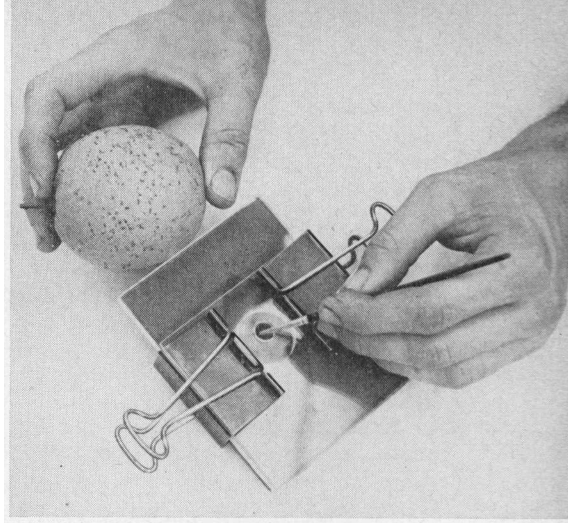

Applying greenhouse thrips to leaf from systemically treated citrus to determine toxic effect, using a Munger cell of isobutyl methacrylate polymer. After insects are placed on leaf, cell is closed by sliding top plate.

Systemic insecticides—compounds which can be absorbed readily by plant foliage and roots and subsequently translocated throughout the plant—render the plant tissues poisonous or unpalatable to juice feeding insect pests.

Systemics have proved effective in controlling aphids and mites on annual crops—such as greenhouse plants, cotton, hops—and their possibilities for the control of juice feeding citrus insects are under study in a comprehensive research program at Riverside. The Divisions of Entomology and Plant Physiology of the University of California Citrus Experiment Station are co-operating.

Inasmuch as systemic action has been found to some degree in several organic phosphorus and fluorine compounds, it was necessary—for the citrus pest investigations—to devise a satisfactory method for the quantitative estimation of systemic action.

Such a test must demonstrate the rate of translocation of the compounds in the plant when applied in various concentrations, and must determine the toxicity of the translocated material to a variety of citrus pests.

Preliminary experiments demonstrated that the most satisfactory results could be obtained by growing five- to six-month-old lemon seedlings in water culture solutions to which were added known concentrations of solutions or emulsions of the test compounds.

Screening Tests

At definite intervals after the beginning of the experiment, leaves were removed from the plant and placed in plastic modified Munger cells where they could be infested with known numbers of citrus red mites, citrus aphids, greenhouse thrips, crawlers of California red, cottony-cushion, black, or other scales, or with almost any citrus pest which sucks the plant juice. Mortality data could then be recorded over a period of several days.

Such tests reveal quite precisely the movement of the toxicant through the intact roots, up the stem and into the leaves, and demonstrates the concentrations in the water culture solution necessary for systemic action.

The use of closed cells—such as the modified Munger cell—is perhaps objectionable on the grounds of possible fumigation effects, but no other practical way of confining the tiny pests has been devised, and no difficulty from fumigant action has occurred in practice.

When the results from the initial screening appeared promising, the compound was tested further by watering it into the soil of potted citrus seedlings and by spraying it on the foliage of similar seedlings.

Plants treated in these ways were then tested by the Munger cell methods and by mass infestation—by numbers of adult mites, aphids, thrips, or by scale crawlers—followed by observation to determine whether the populations declined or increased.

Tests were carried out over a period of several months to determine the duration of toxic action. These tests closely approximate actual field conditions where the systemic material would be applied in irrigation water, or by spraying.

When a compound such as octamethyl pyrophosphoramide — OMPA — gave highly promising results in laboratory tests, it was applied to one or more full-sized citrus trees on the Experiment Station grounds. This was done to assess the effects on natural insect populations of California red scale, citrus thrips, citrus aphids, black scale, cottony-cushion scale, citricola scale, citrus red mite and other pests.

The intensity and duration of the toxic action was further observed by removing leaves and fruit at regular intervals for bio-assay by the use of the Munger cells and similar methods developed for testing toxicity of treated citrus fruits.

Comparison of Contact and Systemic Toxicity to Adult Female Citrus Red Mite, *Paratetranychus citri* (McG.)

Compound	Conc. in per cent	24-hour per cent mortality contact with residue	48-hour per cent mortality systemic action	
			Days after treatment	
			2	7
Parathion	0.01	91	0	0
	0.005	81	..	..
	0.0025	25	..	..
	0.001	9	..	..
Paraoxon	0.01	100	10	80
	0.001	23	0	0
Octamethyl	0.1	77	..	..
Pyrophosphoramide	0.03	..	0	100
	0.01	..	0	100
	0.001	..	0	5

Preliminary Results

The data obtained indicate some of the properties of several organic phosphate insecticides, both as residual toxicants and as systemic insecticides.

Parathion, very highly toxic by direct contact, has little or no systemic action, while its close relative, para-oxon, has considerable systemic action.

OMPA is very weakly toxic to insects by direct action, but is quite effective as a systemic. This lack of toxicity of direct contact is of considerable importance as it prevents destruction of beneficial parasites and predators. This factor should largely eliminate the destructive increases of resistant insects sometimes observed following the use of DDT or parathion. Certain of the newer organic phosphate compounds such as E-1059 and 20/58 show even greater systemic action than OMPA.

OMPA applied to soil about citrus seedlings at 0.1% of the weight of the soil in pots, has given complete kill of citrus red mites for five months. When applied to large citrus trees by spraying at one to two pounds per 100 gallons of water, OMPA treatment has resulted in complete cleanup of natural mite populations for periods of at least three to four months, although adjacent trees are heavily infested. The toxicity to greenhouse thrips and red scale crawlers is of considerably shorter duration.

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SMOG

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nips, and radishes also were damaged by smog. The roots or edible portions of these crops were uninjured, but severe burning and spotting of the tops lowered market value because of poor appearance.

In the table on pages 8 and 9 crops are listed in the order of dollar-value loss due to smog damage.

In the case of alfalfa, only 17% of the Los Angeles County acreage is produced in the area seriously affected by air pollution. The greater portion of the acreage is north of the Sierra Madre Mountains in a desert area far removed from industrial and urban centers. In the case of other crops, such as spinach and parsley, 20% to 100% of the acreage is located in the area of heavy concentration shown in the dark-shaded portion of the map on page 7.

Estimates given in the table are for total 1949 production. Individual crops of spinach may have been a total loss at the particular time they were scheduled for harvest, whereas at other times during the year spinach was undamaged. The same is true of all other crops listed.

In addition to the listed crops there were others that showed damage but evaluation of dollar loss would be exceedingly difficult. For example, the leaf tips of young oats, barley, and onions were scorched. However, these crops overcame the injury sustained during early growth and eventually produced a near-normal yield. Destruction of leaf tissue resulted in delayed maturity in some instances. The longer growing period necessitated additional irrigation, fertilization, pest control, and weeding for crops such as beets and onions. No attempt was made to calculate these losses.

Many types of flowers and ornamental nursery stock—in greenhouses as well as out of doors—have at times had either leaves or flowers, or both, marked by concentrated air pollution. In most cases, the market value was lowered because of poor appearance, and estimates of loss by members of the flower industry ranged from one half to one million dollars. There are no surveys or other reliable data to substantiate these estimates.

The following cultivated plants are listed in order of decreasing susceptibility: *Extreme*—Romaine lettuce, endive, and spinach; *Moderate*—beet, celery, oats, Swiss chard, and alfalfa; *Slight*—barley, onion, parsley, radish, tomato, turnip, and rhubarb; *None*—cabbage, cantaloupe, carrot, cauliflower, cucumber, pumpkin, squash, and broccoli.

A number of weeds also have been damaged by air pollutants, namely: wild oats, *Avena* sp.; lambs quarters or pig weed, *Chenopodium album*, and *C. murale; Malva parviflora* and annual bluegrass, *Poa annua*. Weeds are used as an indication of the extent of air pollution injury because they are often found in zones not ordinarily cultivated. Annual blue-grass is the most susceptible plant observed to date.

Injury to herbaceous plants has been recorded in a triangular area delineated by the cities of Santa Monica, San Clemente, and Redlands. The agricultural districts most seriously affected are those south and east of Los Angeles.

Air pollution damage to susceptible crops is particularly devastating, and is comparable to such catastrophies as fires, frosts, and floods, because it can render a crop worthless almost overnight, with no previous warning. It is a direct function of the weather and of meteorological conditions of the southern California coastal plain. This fact alone makes the problem a difficult one to solve.

Since crops differ in degree of susceptibility to injury, it may be advisable for growers in this area to revise their crop schedules by eliminating the extremely sensitive plants. This will have to be done in order to stabilize their economy until such time as the phytotoxic agent or agents of air pollution are definitely identified and eliminated.

Elimination of the components of air pollution will require diligent research to solve the engineering problems involved, and also will require the establishment of new regulations governing air pollution and means for their enforcement.

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SYSTEMIC

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Studies on systemic insecticides will require several years of experimentation—and the solution of many technical problems—before any practical use can be anticipated. Among the many questions to be answered, the following are readily apparent: *1*, duration of effectiveness at various concentrations to a variety of citrus pests; *2*, most suitable methods for application—whether by foliage spray, irrigation, pressure injection, or soil treatment; *3*, distribution of compounds in citrus plants and possible toxicity of treated fruit to consumer; *4*, distribution of soil applications through the root zone of citrus trees and its effects on soil fertility and possible deleterious effects on citrus or other crops.

Experimental set-up for growing lemon seedlings in water cultures containing systemic insecticides.

Because the answers to many of these questions are difficult to obtain—due to the extremely small amounts of compound present—it is planned to use radioactive molecules as tracers. Such studies should increase current knowledge of insect and mammalian toxicology. They should be valuable also in elucidating the principles governing the translocation and distribution of organic molecules in plant tissues.

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