Improving integrated pest management in Southern California citrus

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On the 30-acre ecosystem study plot established in a commercial navel orange grove at Woodcrest, near Riverside, researchers developed an integrated pest management program applicable to orange and grapefruit orchards from coastal to interior zones of southern California.

The 5-acre size of the ecosystem subplots and their square shapes provided an adequate buffer band to protect the central area, or core acre, against drift of pesticides from adjoining, differently treated subplots. Data from the core acre and the surrounding 4 acres of buffer trees within the same subplot were kept separate. The treatment/management regimes used were superimposed on the growers' usual irrigation, fertilization, and weed control practices.

The data collected include monitored populations of pests and natural enemies; the yields of subplots on both a per-tree and a commercial-pack basis; and grading of the external quality of the oranges. The results through 1975 demonstrate that one of the programs employed can serve as a prototype for a practical integrated pest management program involving 76,000 acres for both oranges and grapefruit in the southern California area, excluding the desert district. Use of the integrated pest management program could result in an estimated savings to those growers of approximately $4,000,000 annually.

Pests

Out of a number of potential insect and mite pests, California red scale, *Aonidiella aurantii* (Mask.), citrus red mite, *Panonychus citri* (McG.), and citrus thrips, *Scirtothrips citri* (Moult.) were the key pests that required control. California red scale is particularly important because without suppression it can kill a citrus tree in a short time.

Aphytis melinus DeBach was introduced against California red scale in southern California in 1956-1957, and its geographic distribution was generally established in interior southern California districts by 1965. *A. melinus* was established in the citrus orchards at Woodcrest at the time the integrated pest management experiment was begun there.

Treatment programs

At prebloom a treatment was not used routinely, but was made only if required for control of citrus red mite. All of the treatment programs included applications of the nutritional minor elements of $ZnSO_4$ and $MnSO_4$ in the spring and in the fall. These materials are water soluble and are applied either by mist spray or low volume techniques. These applications do not seriously upset populations of natural enemies, especially *A. melinus*, the key parasite of California red scale.

The annual schedules of foundation treatments of the treatment/management regimes used for insect and mite control in the study plots at Woodcrest during 1973 to 1975 were the following:

Program A was the recommended organochemical treatment that is general practice in the area. At prebloom, an organochemical acaricide was used if citrus red mite required control. At petal-fall, dimethoate at 1.34 pounds AI/acre was applied by mist spray for citrus thrips. In mid-June, parathion was used for California red scale; an air-blast sprayer, operated at a ground speed of 1.0 miles per hour, was used to apply a spray of 3.75 pounds of parathion AI in 1000 gallons of water per acre. In the September to November period, an organochemical acaricide was used for

Low-volume sprayer with two discharge heads positioned at two heights on an air tower. Improved spray distribution in citrus tree top areas results in better control of red scale and red mite, key pests in an integrated control program.

citrus red mite.

Program B was the biological control treatment and consisted only of minor element spray applications.

Program C was an integrated pest management program. At petal-fall, Ryania was applied by mist spray for citrus thrips; and in September, 10 gallons of narrow-range 415 spray oil plus 22 ml 2,4-D in 100 gallons of spray mixture per acre was applied by low volume primarily for citrus red mite control and secondarily to reduce the number of California red scale at immature stages.

The machines used for September applications were the low silhouette model. Now, models are available commercially with spray discharge heads positioned at two heights on an "air tower." The modification adding on the upper spray discharge heads improves spray distribution coverage in the upper areas of citrus trees. This is important in the control of California red scale and citrus red mite, key pests which may require treatment in an integrated control program. The droplets of the deposit of low volume oil spray are very small, and therefore have little adverse effect on natural enemies.

California red scale

Populations of red scale were measured by determining the mean number of unfertilized ("gray") adult and fertilized adult female scales per 3-inch twig unit from 24 twig sections about 1.5 years old, chosen in the peripheral foliage area at a height of 3 to 6 feet above the ground from five sample trees.

The results showed good control of California red scale under Programs A and C. However, at the end of the second year (1974), the numbers of scale had increased fivefold under the exclusively biological control of Program B.

The amount of N-R 415 spray oil deposited by the low volume treatment of Program C is not enough in itself to produce effective control of California red scale. However, it was known from experiments done by Dr. Walter Ebeling in 1936 that small amounts of spray oil cause high mortality of immature stages of California red scale and the efficiency of spray oil deposit was much greater on the immature stages, even through the gray adult stage, than on the fertile adult female. The low volume N-R 415 spray oil treatment in September did kill a significant portion of the immature stages. This appears to have exerted sufficient suppression on the population so that parasitization of the remaining live scales by *A. melinus* was sufficient to maintain effective regulation of the scale population at low levels.

Citrus red mite

Populations of citrus red mite were measured by counting adult female mites on the terminal four leaves of eight twigs (32 leaves) per tree; the counts were made on eight sample trees of the core acre to provide the mean number of adult female citrus red mites per leaf under each program.

In Program A, it was decided to treat for citrus red mite when the count reached a level of two adult mites per leaf. The first application was made April 14, 1973, with oxythioquinox used at 1.875 pounds AI per acre on mature trees with no fruit present. The applications that followed were propargite at 4.5 pounds AI per acre on November 26, 1973, dicofol at 4.0 pounds AI per acre on July 29, 1974, propargite at 4.5 pounds AI per acre on November 15, 1974, dicofol at 4.0 pounds AI per acre on July 29, 1975, and propargite at 4.5 pounds AI per acre on November 4, 1975. Although development of resistance by citrus red mite to dicofol was probable, it was used in July 1974 and 1975 because propargite, the only other organochemical acaricide available then, cannot be used when the daily maximum temperature is above 90° F.

In Program C, N-R 415 spray oil was used to control citrus red mite with application each year in mid-September. Results showed that control of citrus red mite in Program C was as satisfactory, in general, as that in Program A.

Yield per tree in all subplots was measured in the orchard at the time of picking by recording the number of field boxes per tree on alternate trees in the core acre. Additionally, the packing house furnished a separate pack-out report for each core acre and each of the outside four acres of the respective subplots. As the oranges were picked, ten were taken from each field box to make up a sample for examination in the orchard for rind damage usually responsible for grading diversion to by-products. Later, as each lot of oranges went through the packing house, oranges were taken at random from the by-products belt to make up a sample consisting of six field boxes, which was similarly evaluated for types of rind damage.

The data obtained for oranges with thrips scars were used as indices in comparisons of control of citrus thrips in the different treatment program regimes. The results show that percentages of oranges with thrips scarring were relatively low and indicate that at Woodcrest in 1974 and 1975 citrus thrips was not a pest of major economic importance. Under these conditions no advantage accrued from using dimethoate for control.

The yields in 1974 and 1975 in field boxes per tree, total cartons per acre and percentages of fruit packed in premium grade and in standard grade were as good or better in the integrated pest management program (C) than in the conventional organochemical treatment program (A).

The overall annual costs of insecticides and acaricides and their applications at general commercial rates differed substantially at the Woodcrest experiment among the treatment/management programs. The average annual treatment cost per acre in 1976 for the control of insect and mite pests on oranges in the Riverside area ranged from $100 to $145. The cost of Program A, if fully used, would have ranged from $203 to $239; the modified program actually used cost $158. The cost of Program C was only $54 per acre. The savings from using the integrated pest management treatment regime of Program C could have ranged from $60 to $100 per acre.

Conclusions

Ecosystem subplots of 5 acres each in a navel orange orchard compared pest management in annual treatment programs of conventional choice of recommended organochemical pesticides, biological control, and oil spray in September and a thripicide in the spring. The key pests involved during three years were California red scale, citrus red mite, and citrus thrips. Results showed that an integrated pest management program was required and was demonstrated in Program C. This program was substantially lower in cost and provided as good control of the key pests as the conventional program of recommended organochemical pesticides.

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