Integrated Control Measures

experiments in lemon grove near Carpinteria showed selective miticides to be compatible with biological control of red scale

Paul DeBach, John Landi, and Lee Jeppson

Biological control of California red scale— *Aonidiella aurantii* (Mask.)—by natural enemies, especially parasites, may be achieved in some citrus-producing areas of southern California. However, in many instances other citrus pests present in the same areas may be of sufficient magnitude to necessitate regular or periodic insecticidal treatment.

A field study to evaluate the effects on the red scale parasite *Aphytis* of the more promising materials currently employed in controlling citrus bud mite—*Aceria sheldoni* (Ewing)—and citrus red mite—*Panonychus citri* (McG.)—was carried out in a lemon grove near Carpinteria. A test plot was established in April 1954 to determine if control of the heavy infestation of the Argentine ant—*Iridomyrmex humilis* Mayr—present in the grove would improve biological control of the red scale which, presumably, had been disturbed by the ants.

Scale Infestation

Field counts and laboratory samples taken during 1954 showed a relatively high red scale density coupled with a comparatively low percent parasitization by the naturally present parasite—*Aphytis chrysomphali* Mercet. The dense population of the ant seriously inhibited the activity of parasites and predators of the scale. Chemicals used to control ants are applied to the ground and, therefore, do not affect natural enemies of the red scale on the trees. Late in 1954 ant control was sufficient for the colonization of the scale parasite—*A. lingnanensis.*

In January 1955, five check trees of similar red scale densities were selected for periodic counts of the parasite and scale populations. By August, the red scale infestation had decreased markedly and was under satisfactory biological control.

Index Rating of California Red Scale Population Densities per Tree in Relation to Economic Severity*

Density	Qualitative Rating	
0– 5	Rare	Commercial control
6–10	Scarce	
11–20	Light	
21 up	Medium heavy to very heavy	No commercial control

* Based on the number of live scales on 24 3" samples of twig per tree.

At the end of the pretreatment period—January–August—the red scale density index rating was three per tree-sample, with an average of 19.3% parasitization by *Aphytis* which, in general, is sufficient to effect good biological control. The red scale and parasite populations were more or less uniform througout the test area, and all pests except mites were under good biological control. This situation appeared satisfactory for initiating tests of miticides to evaluate their effects on biological control of red scale.

Materials Tested

The initial six-acre plot was subdivided into four plots, each of which received Chlorobenzilate for the control of citrus bud mite plus one other miticide for the control of citrus red mite. Earlier field tests in other plots have demonstrated that Chlorobenzilate has no measurable detrimental effect on the parasites and predators of citrus insects.

Spray treatments were applied only as mite increases dictated, the first in August 1955, the second in April 1957, the third in September 1957, and the fourth in April 1958. The combinations of materials used are listed in the table on the right except that in plot No. *1* no Tedion was used in the 1955 spray. Final scale population counts were made in December 1958.

The center table shows the average red scale density and the average percent parasitization before and after the three-year treatment period. Throughout the treatment period there was no significant change in host-parasite trends following each successive spraying, and the average red scale density of all plots remained well below the economic threshold of 20 scales per tree-sample as based on the index rating, although the plot *3*—Delnav—rating was higher than might be desired. The percent parasitization in each plot also compared favorably with that prior to treatment, indicating that, at the dosages used, none of the materials tested were of sufficient toxicity to upset appreciably the biological control program in this grove. However, plot *3*, with the highest scale density, did not exhibit a correspondingly higher degree of parasitization, and parasitization in plot *4*—Trithion—was somewhat low as compared to plots *1* and *2*. Plot *1*—Chlorobenzilate and Tedion—was the best.

Laboratory tests by other workers showed that Tedion possesses relatively low toxicity to most insect parasites and predators, whereas Kelthane, Delnav, and Trithion—in the order named—are increasingly toxic to some adult parasites and predators. It is possible that Kelthane, Delnav, and Trithion had some inhibiting effects on the parasite-host relationship, even though satisfactory biological control was maintained in each instance. Trithion, at the dosage used, is not an effective treatment for red scale, yet it may have accounted for some mortality of the early stages of red scale in Plot *4* as well as some parasite mortality—one effect perhaps tending to balance the other. It is doubtful whether any of the other treatments had any measurable

Concluded on page 15

Effect of Four Applications of Miticides During a Three-Year Period on Average Population Density of California Red Scale and Average Parasitization by *Aphytis**

	Populations				
	Pre-treatment Aug. 1955 Av./grove	Posttreatment Dec. 1958 Plot			
		1	2	3	4
Density rating	3.0	3.8	5.5	10.3	4.4
Parasitization*	19%	29%	26%	19%	15%

* Percent parasitization, as used here, does not depict total parasite-caused mortality, as the scale mortality caused by adult parasites feeding on the scale body fluids is not included. In general, an average parasitization of 20% by *Aphytis* will effect good biological control.

Chemical Mite Control Treatments Tested

Plot No.	Materials applied		Application/100 gals. water
1	Chlorobenzilate	25% EC[b]	1 pt.
	Tedion[a]	25% WP[c]	1 lb.
2	Chlorobenzilate	25% EC	1 pt.
	Kelthane	18.5% EC	1½ pts.
3	Chlorobenzilate	25% EC	1 pt.
	Delnav	25% EC	1½ pts.
4	Chlorobenzilate	25% EC	1 pt.
	Trithion	50% EC	12 oz.

[a] Not incorporated in the first spray application.
[b] EC—emulsifiable concentrate.
[c] WP—wettable powder.

Application of Prior Research

accumulated information obtained by research often provides ready solutions to many problems of agricultural production

Paul F. Sharp

The immediate commercial value of research information enabling scientists to solve rapidly many of the problems facing agriculture has been demonstrated repeatedly; what might have happened without this information is awesome to contemplate.

Less than 20 years ago a noxious weed was discovered in the Klamath River Valley. The weed—called Klamath Weed—was toxic but not fatal to cattle and sheep. It spread rapidly until it infested some 400,000 acres of rangeland and crowded desirable range forage plants. Botanists identified the weed as the St. John's-wort, a plant native to Central Europe where it was kept controlled by a small beetle that would eat nothing else. War conditions prevented obtaining specimens for colonization in California. Entomologists identified two varieties of the beetle as those taken to Australia years before to combat the St. John's-wort infestations there. Because the beetles were native to the Northern Hemisphere, entomologists—by drawing on previous research—were able to reverse the life cycle of the beetles so they could live in Australia. California entomologists obtained specimens of the beetles in Australia, brought them back to the Northern Hemisphere, returned their life cycle to that in Middle Europe. The scientists propagated the beetles in the insectary until sufficient quantities were available for colonization in the Klamath Weed infested ranges of northern California. The beetles became established and spread rapidly. The Klamath Weed, that once threatened some 400,000 acres of California rangeland, is no longer an economic problem in most areas. If findings of research had not been available, cattle and sheep ranchers might have been forced out of much of northern California. Instead, a monument to the Klamath Weed beetle has been erected at Eureka.

On May 26, 1953, an outbreak of the rice leaf miner was reported in Colusa County. On May 28—three days after the outbreak was detected—control treatments were started. Insecticides—available after years of research in chemistry—were applied by airplane, which in itself resulted from many years of study. Between 10% and 20% of the rice crop was destroyed at a loss of about $16,000,000. In addition, $1,200,000 were spent for insecticide control. However, more than 200,000 acres were treated and within 48–96 hours after treatment 99% to 100% of the rice leaf miner larvae were dead. From 10 to 17 days after treatment the rice plants began to show new healthy growth. Again, information available through research made it possible to save most of the 1953 rice crop in the Colusa area.

A third example began in February 1954 when a single aphid taken from a burr clover plant in San Diego County was identified as a specimen of the spotted alfalfa aphid.

The first economic outbreak of the spotted alfalfa aphid in California was detected in the Imperial Valley, late in June 1954, and spread into Riverside and San Diego counties.

Insecticides such as parathion, malathion and Systox—new materials produced after years of research—were available and applied as sprays to infested alfalfa fields.

The insecticides curbed the aphid in treated areas but new infestations developed. Before the end of 1955 an estimated 726,680 acres of alfalfa in 23 counties of the state were infested. In 1956 the aphid began to develop strains resistant to parathion and, to some degree, to malathion.

In the meantime—because agricultural scientists suspected the spotted alfalfa aphid was controlled by natural enemies in the Middle East—three species of parasitic wasps from the Mediterranean area and four predators of the aphid from India were introduced to California.

Insect pathologists found at least five species of fungi capable of producing epizootics—epidemics—among the aphid. Some 1,800 cultures of the fungi were placed in infested fields in 12 alfalfa producing counties.

Scientists in Nevada—employing the principles of genetics—had developed a new variety of alfalfa, for local climatic conditions. The new variety, Lahontan, is resistant to the aphid and is replacing susceptible varieties in some new alfalfa plantings in California, although plant breeders are far along in a program designed to incorporate the resistance of Lahontan to varieties more suited to California climatic conditions.

The effectiveness of the control measures put into operation because of the availability of the results of years of research in many sciences is again reflected in the case of the spotted alfalfa aphid. A year after the aphid was discovered in California crop damage and treatment costs amounted to more than $12,000,000. Three years later the loses had dropped to $1,694,064.

If scientists did not have the accumulated knowledge developed through research available for swift application, the agricultural economy of California—and the United States—would be subject to sudden and unknown changes.

Paul F. Sharp is Director, California Agricultural Experiment Station, University of California, Berkeley.

LEMONS

Continued from page 12

direct effect on the population of the red scale.

The results of the Carpinteria experiment showed that, when used in conjunction with Chlorobenzilate, Delnav and Trithion were associated with somewhat reduced parasitization in the field, Tedion exhibited no appreciable laboratory or field toxic effects, and Kelthane showed little if any effect on parasitization in the field.

The experiment also reaffirmed that efficient ant control is essential in maintaining a satisfactory degree of biological control of California red scale and that biological control can be greatly enhanced if selective insecticides only are used, to avoid upsetting the parasite-host relationship.

Paul DeBach is Entomologist in Biological Control, University of California, Riverside.

John Landi is Technician in Biological Control, University of California, Riverside.

Lee Jeppson is Associate Entomologist, University of California, Riverside.

The above progress report is based on Research Project No. H-1493.