H. H. SHOREY · R. L. HALE

Control of GREEN PEACH APHID *on Peppers*

THE GREEN PEACH APHID is probably the most serious pest of peppers in the United States. Until recent years, the aphid has been adequately controlled on peppers in southern California by the use of various organic phosphate insecticides. Recently, however, an increase in the tolerance of green peach aphid populations to several commonly used aphicides—including TEPP, malathion, parathion, diazinon, and Phosdrin—has become apparent in many areas. Similar difficulties have been reported from other regions of the United States. In an attempt to reduce aphid densities, most growers engage in an aggressive insecticide-application program. As the aphids become increasingly resistant to an insecticide and more difficult to control, the insecticide is often applied at increasingly higher rates, and shorter intervals. Under these conditions a poor degree of control is usually obtained, and the aphid populations build up rapidly to the pretreatment levels or higher.

In the absence of insecticides, the green peach aphid is attacked and often successfully controlled by a variety of beneficial insects, including lady beetle adults and larvae, green lacewing larvae, syrphid fly larvae, and a new wasp parasite—*Aphidius matricariae*. A decline in numbers of the green peach aphid in recent years has coincided with the spread and increase in numbers of the parasite.

It appears that an ideal aphicide for use on peppers should be selective, to kill aphids but spare beneficial insects, or persistent, to give continued plant protection if beneficial insects are not present.

A large number of experiments were conducted from 1959 through 1962 to evaluate new insecticides and application methods for control of the green peach aphid on peppers in southern California. Data from five experiments discussed in this report are also supported by other experiments, not shown here. Experimental plots were one to three rows

The green peach aphid is attacked by a number of beneficial insect species which keep aphid densities suppressed much of the time. Increased resistance of the aphids to many commonly used organic phosphate insecticides has occurred. Intelligent use of selective insecticides, which destroy the pests but spare many beneficial insects, is one of the best approaches for green peach aphid control on peppers, according to these tests.

wide by 20 to 40 feet long, and each treatment was replicated four times in a randomized complete block design. In experiments 1, 2, and 3, the insecticides were applied to the foliage by hand-operated sprayers or dusters. In experiments 4 and 5, the insecticides, formulated as granules, were distributed uniformly along a trench which was opened with a hoe between the plant row and the irrigation furrow. Trenches were about 3 inches deep and 4 inches from the plant row. They were closed immediately after application, and the fields were irrigated within 24 hours.

The control given by the various insecticides was evaluated by counting the number of wingless aphids on a predetermined number of leaves selected at random. Eighty to 160 leaves per treatment were examined on each counting date in each experiment.

Foliage applications

Three of the insecticides applied to the foliage consistently gave good, persistent control of the green peach aphid. These materials were endosulfan (Thiodan) as a dust or spray and dimethoate and phosphamidon as sprays. Endosulfan, a chlorinated hydrocarbon insecticide, is relatively slow in action and generally required three days to suppress aphid populations to their lowest levels. Endosulfan applied as a spray has been very effective at rates as low as ½ pound of toxicant per acre. As a dust, however, a 0.5-pound rate showed a tendency to be less effective than a 1.2-pound rate. Many observations of treated fields have indicated that endosulfan is highly selective, being considerably more toxic to green peach aphids than it is to such beneficial insects as lady beetles and the parasite *Aphidius matricariae*.

The systemic nature of dimethoate and phosphamidon causes aphids feeding on the lower surfaces of leaves to also be exposed because the toxicant penetrates the leaves. This may help to explain why these materials remain highly effective against the green peach aphid while

TABLE 1. EFFECT OF INSECTICIDES ON THE GREEN PEACH APHID ON PEPPERS

Treatment	Pounds toxicant per acre	Number of aphids per 100 leaves after days shown: 1	4	7
Experiment 1: Dust applications—San Diego County—October, 1959				
Endosulfan	1.2	49a	9a	
	0.5	80a	44ab	
Diazinon	1.0	107a	217bc	
Parathion	0.8	257b	482cd	
Untreated	..	571b	1217d	
Experiment 2: Spray applications—Riverside County—May, 1960				
Endosulfan	0.6	75a	18a	19a
Phosphamidon	1.1	17a	11a	53ab
Untreated	..	258b	203b	125b

a,b,c,d Numbers in the same column followed by the same letter are not significantly different (5% level).

TABLE 2. EFFECT OF INSECTICIDES ON THE GREEN PEACH APHID ON PEPPERS, RIVERSIDE COUNTY, APRIL, 1960

Treatment	Pounds toxicant per acre	Experiment 3 Number of aphids per 100 leaves after days shown: 1	3	7	14	20
DUSTS						
Endosulfan	1.6	56ab	5a	13a	19a	39b
Dimethoate	1.1	258c	193bc	428bc	725b	274c
Diazinon	0.8	104b	204bc	588bc	692b	172c
SPRAYS						
Endosulfan	1.4	60ab	7a	11a	31a	6a
Dimethoate	1.2	28a	25a	8a	15a	19ab
Diazinon	1.2	59ab	58b	281b	697b	248c
UNTREATED	....	459c	557c	989c	1240b	168c

a,b,c Numbers in the same column followed by the same letter are not significantly different (5% level).

many other organic phosphate insecticides have become relatively ineffective. Dimethoate carried in a liquid probably penetrates the leaf much more readily than it does from a dust particle, explaining why the sprays were more effective than the dusts.

Soil applications

In experiment 4, dimethoate and Di-Syston were applied in the soil for control of a potentially damaging infestation of green peach aphids. Dimethoate acted more rapidly than Di-Syston. However, no systemic insecticide applied in the soil has given sufficiently high and rapid control, at the dosages tested, to suggest that this method of application can effectively and quickly reduce a prevailing green peach aphid infestation on peppers.

Experiment 5 was applied in January, when the pepper plants were growing slowly; green peach aphids did not appear in large numbers until about nine weeks later. At that time (between two and three months after application), dimethoate was no longer providing effective control. Di-Syston, however, caused more than 95% reduction of green peach aphids. The use of long residual systemic insecticides such as Di-Syston for the prevention of later aphid population increases on peppers is receiving further study.

Natural and integrated control

It is noteworthy that marked decreases in green peach aphids occurred in the untreated plots of most experiments. This probably occurred in most cases as a result of the increase in numbers of beneficial insects.

Close supervision of pepper fields is essential if the naturally occurring beneficial insects are to be used to best advantage. Frequently, green peach aphid density increases are rapidly followed by similar increases in numbers of a variety of beneficial species. If insecticide treatments are withheld, aphid numbers reach a peak and then quickly decline due to their destruction by the beneficial insects. Soon, an excess of the beneficial forms occurs, causing a continued reduction of aphids until very few remain. Such a rapid reduction of aphids occurred in the untreated areas in experiment 4 between the second and third weeks, and in experiment 5 between the 11th and 12th weeks.

Sometimes the peak population of aphids is considered to be sufficiently high to cause economic damage. In such cases insecticides may have to be applied, even though a population of beneficial insects is increasing. When possible, a selective insecticide such as endosulfan should be used to suppress the aphids but spare many of the beneficial insects. This type of control program, which integrates the action of a selective insecticide with beneficial insects, should ideally provide better aphid control with fewer insecticide treatments than a similar control program using non-selective insecticides.

Dimethoate and Di-Syston are not yet registered for use on peppers or as a soil treatment. When such materials become available, the opportunities for integrated control of aphids on peppers will be further enhanced. Systemic insecticides applied to the soil are probably very selective in action; although aphids that obtain fluids from the plants grown in the treated soil may be killed, beneficial insects are not contacted directly.

H. H. Shorey is Assistant Entomologist and R. L. Hale is Laboratory Technician IV, Department of Entomology, University of California, Riverside.

TABLE 3. EFFECT OF SOIL APPLICATIONS OF GRANULATED SYSTEMIC INSECTICIDES ON THE GREEN PEACH APHID ON PEPPERS, RIVERSIDE COUNTY, MARCH, 1962

Treatment	Pounds Toxicant Per Acre	Number of Aphids per 100 Leaves After Weeks Shown						
		Experiment 4			Experiment 5			
		1	2	3	9	11	12	15
Dimethoate	2	264a	335a	133b	166b	1105b	84ab	23b
Di-Syston	2	961b	391a	12a	23a	51a	32a	4a
Untreated	.	929b	1663b	49ab	408b	2140b	212b	8ab

a,b Numbers in the same column followed by the same letter are not significantly different (5% level).

GRASSLAND ASPECTS OF SOIL-VEGETATION SURVEY

RANGE MANAGEMENT information developed by the Department of Agronomy has been a valuable supplement to basic maps of the State Cooperative Soil-Vegetation Survey. Soils and accompanying vegetation have been mapped on some nine million acres of California uplands. Financed principally by the California Division of Forestry, the Survey is conducted by the Pacific Southwest Forest and Range Experiment Station, U. S. Forest Service, in cooperation with the University of California.

Percent ground cover of herbaceous species has been measured on some 1,200 type-acre plots—areas considered representative of the soil and vegetation on which they are located. Nutrient responses have been assayed with greenhouse pot-tests for 100 soil samples of 30 soil series. Eleven of these same soils have been studied on 20 range fertilizer trials for interactions of resident herbaceous species composition, herbage production, and fertilizer application of nitrogen, phosphorus, and sulfur—the major elements of range fertilization.

A summary of results from one soil series—Millsap—illustrates the information developed. The Millsap soils generally support a woodland-grass vegetation. The woody overstory of 20% to 50% cover consists mainly of blue oak. Herbaceous vegetation is composed of soft chess, slender wild oat, red brome, annual fescues, medusahead, ripgut, a small amount of other annual grasses, a very small amount of perennial grasses, broadleaf filaree, cut-leaf filaree, bur clover, true clovers, and a number of other forbs. The composition varies from one location to the next and from year to year. Removal of woody vegetation increases total herbaceous cover.

Greenhouse tests of four samples of Millsap soils showed all to be deficient in nitrogen. One sample was further deficient in sulfur and another in both sulfur and phosphorus.

Results of a field fertilizer trial on an area cleared of woody vegetation indicated increased herbage yield and species composition changes in relation to applications of nitrogen, nitrogen-sulfur, nitrogen-phosphorus, and nitrogen-phosphorus-sulfur. In general nitrogen increased the percentage of broad-leaf filaree and soft chess. Bur clover and true clovers could be important on the plot in "good clover years," as a result of a favorable combination of weather factors.—*W. Robert Powell, Department of Agronomy, University of California, Davis. Experiment Station Project 1691.*