E. I. SCHLINGER AND E. J. DIETRICK

Biological control of insect pests aided by

Strip-farming Alfalfa

in experimental program

Biological control of the spotted alfalfa aphid—*Therioaphis maculata* (Buckton)—in California became a rapid success after three species of parasites were introduced in 1956.

Studies of alfalfa insect problems during 1956–59 revealed that biological control can be helped by a strip-farming program designed to conserve the natural enemies of the insect pests.

A strip-farming program is essentially the harvesting of alternate strips so there are two different aged hay growths in the same field. When each set of alternate strips is cut, the other strips are about one-half grown and the field is never completely bare of hay. In this way a better and more reliable population balance between the different pest species and their natural enemies can be obtained and retained in a given field.

The conservation of natural enemies results in maintaining the different pest species at population densities below the economic level throughout the year and minimizes the need for applying any kind of insecticide.

Although no experiments have been specifically designed to apply insecticides to the strip-farming program, a simple experiment was carried out against the spotted alfalfa aphid in Kern County. In October 1957, Systox was applied only to the strips of tall hay in a strip-farmed field of alfalfa. Later investigation showed that the surviving beneficial insects had migrated to the short hay strips, rather than away from the field, and had effectively held the aphid in check through the next cutting.

A 70-acre field of alfalfa near Brawley was selected for a comparative experiment. The alfalfa was a ten-year-old stand of African variety that had had two insecticide treatments applied in 1958; one for worms and one for aphids. Observations made in November 1958 revealed a rapidly increasing spotted alfalfa aphid population with but few predators and parasites. The initial problem was to partially control the aphids without losing the alfalfa stand or killing the beneficial species which were just starting to reproduce and become important. Because the field was to be grazed by sheep within a month, the sheep were put on one half of the field. A low dosage of the selective insecticide, Systox, was applied to the other half of the field where the sheep would not be grazing for two weeks. The sheep—and the natural enemies of the aphid—prevented extensive damage to the grazed half of the field. The Systox gave a selective kill to the aphid on the treated half of the field in such a manner that fair populations of natural enemies built up without extensive loss of hay or stand quality. In February 1959, population samples indicated that many species of natural enemies, which are found in untreated fields but not in treated fields, were well distributed throughout the 70 acres. Thus during the winter months the natural enemy populations were built up sufficiently to control any pest outbreak during the rest of the year. This was done without apparent loss to the alfalfa stand or yield.

Important Natural Enemies of the Spotted Alfalfa Aphid
Brawley, June 1959

Natural enemies	Average number per acre		
	Regular farming	Strip-farming	Increase
Lady beetle			
adults	46,000	205,000	159,000
larvae	11,000	232,000	221,000
Green lacewing			
larvae	195,000	206,000	11,000
Parasitic wasps	70,000	287,000	217,000
Big-eyed bugs	199,000	401,000	202,000
Predatory			
spiders	105,000	1,094,000	989,000
Totals	626,000	2,435,000	1,809,000
Total per sq. ft.	14	56	42

For further study, the field was divided into two equal parts. One part was set up for a regular-farming program and the other part for strip farming. Insect populations in both parts were sampled by the conventional sweep-net and by a suction-collecting machine. Because the machine sampled all living arthropods—insects, spiders, mites, and so forth—

Strip-farming of alfalfa, showing plants in different stages of development.

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Vacuum cleaner principle applied in

Sampling Insect Populations

in alfalfa fields by new machine method

Accurate estimates of the total insect population of an alfalfa field can be obtained by the use of newly developed equipment and sampling techniques. All species of insects—each in relation to the whole as well as one to another—and measurement of the separate life stages, and appraisal of the ratios of the beneficial biological control organisms to the harmful plant-feeders can be made.

The new method of sampling uses a suction machine that works on the principle of the vacuum cleaner and gathers all of the alfalfa-inhabiting insects into a collecting bag, made of organdy cloth, so completely that reliable estimates of the true population levels per acre can be derived. A high-speed fan driven by a gasoline motor was adapted to suck insects, from square-foot areas of an alfalfa field, into the collecting bag. The insects from five separate square-foot areas constitute a single machine sample unit.

Two persons are needed to obtain a sample properly. With the motor fan drawing air into a 15′ × 14″ flexible tube, the operator carries the collecting nozzle above his head from one square-foot drop to another drop. An assistant keeps the motor fan away from the area to be sampled to avoid disturbing the insects. The operator lowers the nozzle over the hay and pushes it quickly to the ground. The operator cuts the alfalfa stems encircling the nozzle. The nozzle is then tilted enough to allow the operator to cut the alfalfa stems within the nozzle and shake them to help the air flow dislodge insects held by the leaves. The nozzle is again pressed to the ground for a few seconds over the exact outline of the square-foot area. Then, as the assistant raises the nozzle, the operator quickly fits a smaller adapter hose into the nozzle. The increased air suction in the smaller hose gathers the heavier insects and the trash left in the square-foot area. Five separate square-foot areas are sampled before the collecting bag is removed, quickly taped shut before the motor fan is stopped, and a fresh bag installed. A five-square-foot sample can be obtained in 10 minutes by an experienced team of collectors.

Gathered insects must be kept alive. Portable ice boxes provide refrigeration from the time of collection until the samples are ready to be transferred to funnel separators in the laboratory. A very short exposure of the samples to carbon dioxide anesthetizes the insects so they can be transferred to the separators. In the laboratory the material is spread over transparent plastic-coated screen trash trays in the funnels and the covers are placed in position. The funnels are blacked out except for a beam of light directed up from below the alcohol jar into the center of the funnel. Automatic timers turn the lights on and off every 15 minutes to avoid boiling of the alcohol. Seventy-five-watt glocoil heaters, controlled by powerstats, warm the samples slowly to 120°F. Thus, gradients of heat and light, as well as any positive geotropic responses, cause the insects to leave the duff and become

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within one square foot of area of alfalfa from the ground up, rather than just parts of certain insect populations, the machine-collected samples proved to be far superior to the net samples. Consequently the machine samples were used in the studies.

Altogether, 45 square feet of alfalfa were sampled completely every two weeks, and all insects, spiders, and mites collected were later counted in the laboratory. There were approximately 250 species of these organisms found living in alfalfa from February to September, 1959. Most, if not all, of the potential or real pest species present in the 70-acre field responded to the strip-farming program in about the same manner as did the two most important pest species groups—the spotted alfalfa aphid and worms—and their natural enemies.

That strip farming greatly aided the conservation of natural enemies of the spotted alfalfa and pea aphids, without producing economic infestations of the aphid species, was demonstrated by the fact that four times as many natural enemies were produced in the strip-farmed alfalfa as were produced in the regular-farmed alfalfa.

The major natural enemies studied included three species of lady beetles, two species of green lacewing larvae, three species of hover fly larvae, three species of imported internal wasp parasites, two species of big-eyed bugs, two species of damsel bugs, two species of pirate bugs, and four species of aphid-eating spiders for a total of 21 species.

At times during the year the regular-farmed alfalfa had about as good a natural enemy-aphid ratio as did the strip-farmed alfalfa, but not when the aphids had reached levels of economic importance. For example, in June and July the spotted alfalfa aphid was a serious problem in the regular-farmed field and great damage occurred. At the same

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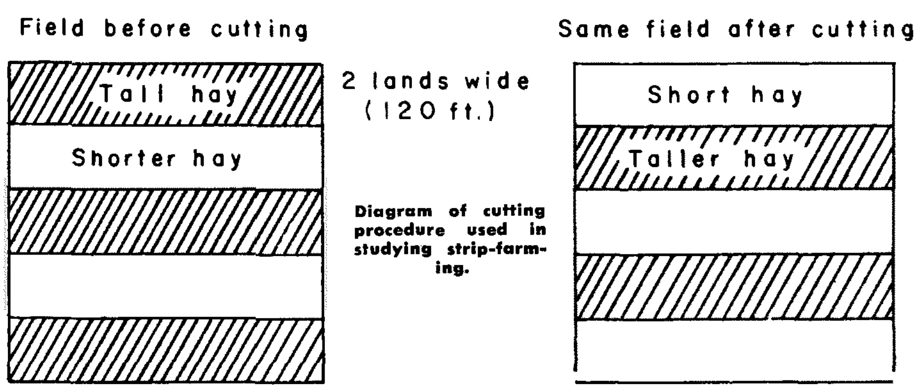

Diagram of cutting procedure used in studying strip-farming.

O. A. LEONARD

Repeated applications of herbicides to

Live Oak Sprouts

essential for complete kills

Live oak—*Quercus wislizenii*—sprouts that develop after burning or bulldozing make conversion of a site to grass a difficult task.

Repeated individual plant treatments by foliage applications of herbicides are essential if complete kills of live oak sprouts are to be obtained. In some cases, the initial sprays may be wasted unless follow-up spraying is conducted.

Experiments were undertaken to evaluate the effect of 2,3,6-trichlorobenzoic acid, polychlorobenzoic acid—mixtures—and amitrol on the kill of live oak sprouts. The benzoics were formulated as the emulsifiable acids and as the salts. Three phenoxy preparations known to be effective against live oak sprouts—with repeated applications—were included for comparative purposes. The test preparations were 2-(2,4,5-TP)—silvex, 2,4-D amine, and mixtures of the esters of 2,4-D and 2,4,5-T. The concentration of 2,4-D amine was varied considerably to correspond to similar variations in the benzoics.

Live oak sprouts were not killed by any of the chlorinated benzoic acids, regardless of concentration to 32 pounds of acid equivalent per 100 gallons of water. Amitrol was relatively poor in comparison with the phenoxy herbicides, except in the August treatments. The best kill with amitrol was obtained in August 1956 when an application containing eight pounds of amitrol per 100 gallons of water resulted in a kill of 80% of the live oak clumps treated. Treatments applied in August 1958 severely affected the plants, but none of the plants was completely killed.

Brush killer—a mixture of the esters of 2,4-D and 2,4,5-T—was the best killer where a variety of brush species were treated. Under such conditions, treatments were made in the spring and early summer before growth had ceased. Poorest kills occurred under hot, dry conditions. Live oak appears to become even more sensitive to brush killer after mid-fall, if rains occur. Winter and spring applications have been satisfactory when the plants had not lost too many leaves before treatment.

Silvex was generally more effective against live oak sprouts than was brush killer, which was especially evident in the reduction of the size of the shoots. Apparently silvex has its greatest advantage over brush killer in the late spring when shoot growth is active. Silvex may not be more effective than brush killer at other times of the year, except in reducing the amount of shoot growth. In these experiments silvex was less effective than brush killer against some woody plants, such as toyon and coffeeberry.

The amine salt of 2,4-D was more erratic in killing live oak than either brush killer or silvex. Amine appears to be relatively poor during the hot, dry periods of the year. However, rain falling soon after application may wash it off the shoots, which would markedly reduce its effectiveness. Amine was most effective during the late fall, winter, and spring and it has, at times, given better kills than any other treatment. Actual sprout kill is related to treatment dosage and under some conditions, complete kills were obtained. The addition of ½% oil to the 32-pound amine treatment increased the sprout kill an average of about 10%.

Effect of Brush Killer, Silvex, and 2,4-D Amine on the Kill of Live Oak Sprouts. El Dorado County.

Date	Brush killer	Silvex	2,4-D amine			
	Pounds acid equivalent per 100 gal.					
	4	4	4	8	16	32
	%	%	%	%	%	%
Aug. 1956	10	10	10	0	10	60
Nov. 1957	60	60	40	60	80	100
Apr. 1958	20	20	20	70	80	100
June 1958	30	70	0	10	20	60
Aug. 1958	10	10	0	0	20	20
Oct. 1958	50	30	0	30	30	60
Feb. 1959	20	0	10	0	40	70
Average	29	31	11	24	40	67

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STRIP-FARMING

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time, the ratio of natural enemies to the aphid was very favorable in the strip-farmed field and no economic loss occurred.

Similarly, twice as many natural enemies of the worms were produced and retained in the strip-farming program as in the regular-farming program.

The 32 species of the major natural enemies of worms studied included one species of egg parasite, two species of egg-larval parasites, seven species of larval and pupal parasites, two species of predaceous earwigs, seven species of beetles, three species of spiders, four species of big-eyed bugs, two species of damsel bugs, two species of pirate bugs, and two species of green lacewing larvae.

The total numbers of worms in the regular-farmed and in the strip-farmed fields were often similar. However, the worms in the strip-farmed field never developed to maturity and did not cause economic damage to the alfalfa, simply because of the better ratio of natural enemies to the pest. On the other hand, worms in economic proportions did develop to maturity in the regular-farmed field and caused considerable loss of alfalfa.

Of the six most important natural enemies of aphids, the green lacewing larva population appeared to be the least altered by the farming method used in the tests.

In each square foot of the strip-farmed alfalfa there were 56 aphid-eaters as compared to 14 aphid-eaters in the regular-farmed alfalfa. If a flight of aphids had occurred during that period the aphid-eaters in the strip alfalfa could have controlled the aphids, whereas it is doubtful if such would have been the case in the regular-farmed alfalfa.

Yield records showed that the strip-farmed field produced 3,942 bales of hay, while the regular-farmed field produced only 3,360 bales, nearly 15% less than the strip-farmed field.

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