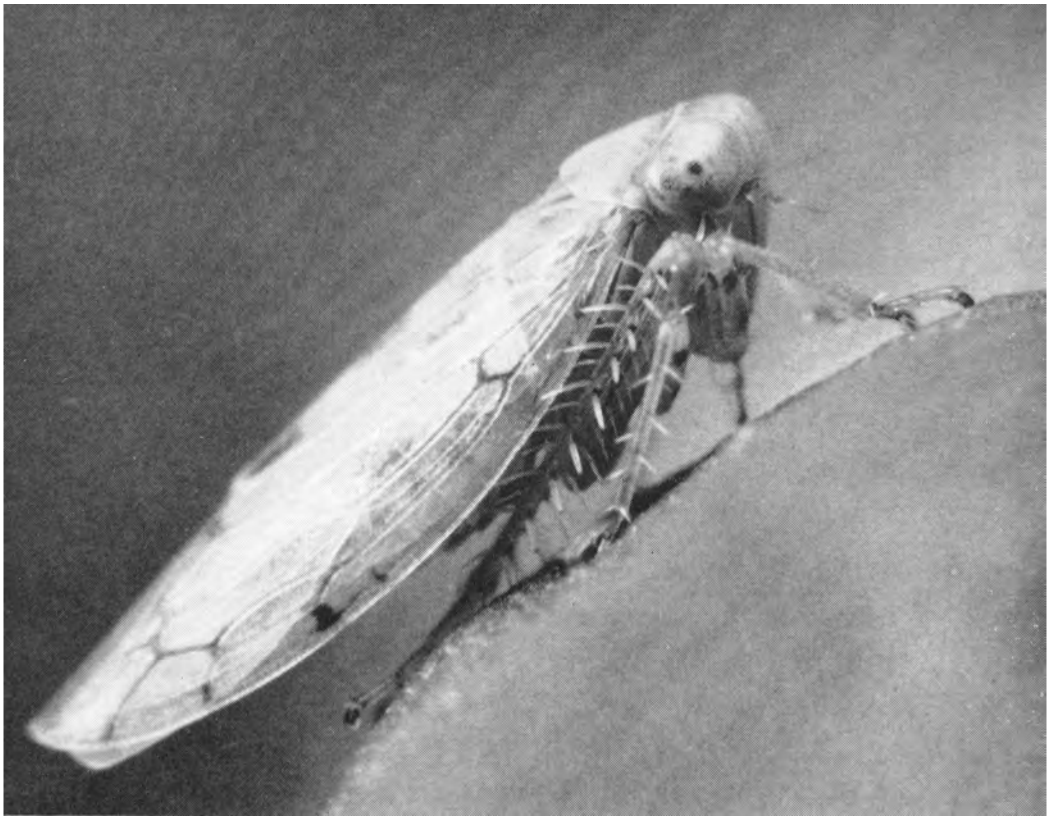

The beet leafhopper, vector of the curly top virus.

# SYSTEMIC INSECTICIDES

## *Reduce the Curly Top Of Sugar*

CURLY TOP VIRUS of sugar beet, named for the severe curling and distortion it causes to the leaves of infected plants, is transmitted through the feeding activities of the beet leafhopper (*Circulifer tenellus*, Baker). Because the virus can be transmitted in only a few minutes of feeding, control of the leafhopper could theoretically be achieved only by insecticides which kill faster than it takes the insect to complete a transmission feeding.

Such drastic control was hardly feasible before the advent of modern synthetic insecticides, and early research attention was directed toward the development of virus-resistant varieties of sugar beets. Studies of the biology and ecology of the beet leafhopper were also undertaken at the same time as a means of understanding and predicting outbreaks of the insect and the virus.

Both studies yielded substantial benefits to California sugar beet growers. The development of resistant varieties has made possible the production of reasonable yields even in years of high beet leafhopper incidence. However, plants of the resistant varieties can still be seriously affected if they are infected during the early stages of growth. The ecological studies revealed that in California the insect congregates and overwinters in certain localities in the foothills of the interior valleys. This valuable information resulted in establishment of an annual control program by the California Department of Agriculture which (at a moderate cost) is believed to have contributed substantially toward curtailing the number of leafhoppers migrating into crops each spring.

Despite the annual control campaign and the use of resistant varieties, the need for protection at the crop site still remains. This need became more acute with the recent expansion of sugar beet cultivation into the Coachella and Antelope valleys. Here the presence of vast acreages of suitable weed hosts favors large increases in the leafhopper population. To meet this need, investigations were initiated at the University of California, Riverside, into the possibilities of limiting the spread of the virus by the control of the vector.

### Systemic insecticides

Although a number of contact insecticides were examined, emphasis was eventually placed on systemic insecticides since these compounds afford a better and longer-lasting coverage of young, actively growing plants. A series of promising systemics were tested in the greenhouse to determine their speed of action against the beet leafhopper, as well as the possibility of phytotoxicity to the plants. The insecticides were formulated as granules and were applied to the soil in flower pots at the time of seeding. At various time intervals thereafter, beet leafhoppers were confined in small cages on these plants, and were observed hourly for symptoms of poisoning. Among the compounds tested, Thimet (phorate) appeared very promising, and since it had already been licensed for use on sugar beets, it was put to further field testing for the control of the beet leafhopper.

### Test plots

A field of September-planted beets near Thermal, Coachella Valley, California, was divided into eight plots, each approximately 100 x 1200 ft. Four of these were used as controls and four were treated as follows: (1) Thimet—10% granules—side-dressed in a narrow band 1 inch to the side of the plants and 2 inches deep at the time of the first cultivation (about 20 days after planting) at the rate of 10 lbs per acre. (2) A second treatment of Thimet granules, at the same rate as before, was applied topically on the plants 36 days after the first treatment. This type of application is possible only if the leaves of adjacent plants in the row are touching and there is little or no ground exposed. The leaves thus funnel the granules to the crown of each plant.

Evaluation of the treatments was based on the extent of the incidence of curly top virus in the treated and control plots. This was correlated with changes in the leafhopper population in the plots following application of the insecticide. An index of insecticidal activity in the plants was also obtained throughout the period of the experiment by confining leafhoppers on these plants and determining the rate at which they were affected.

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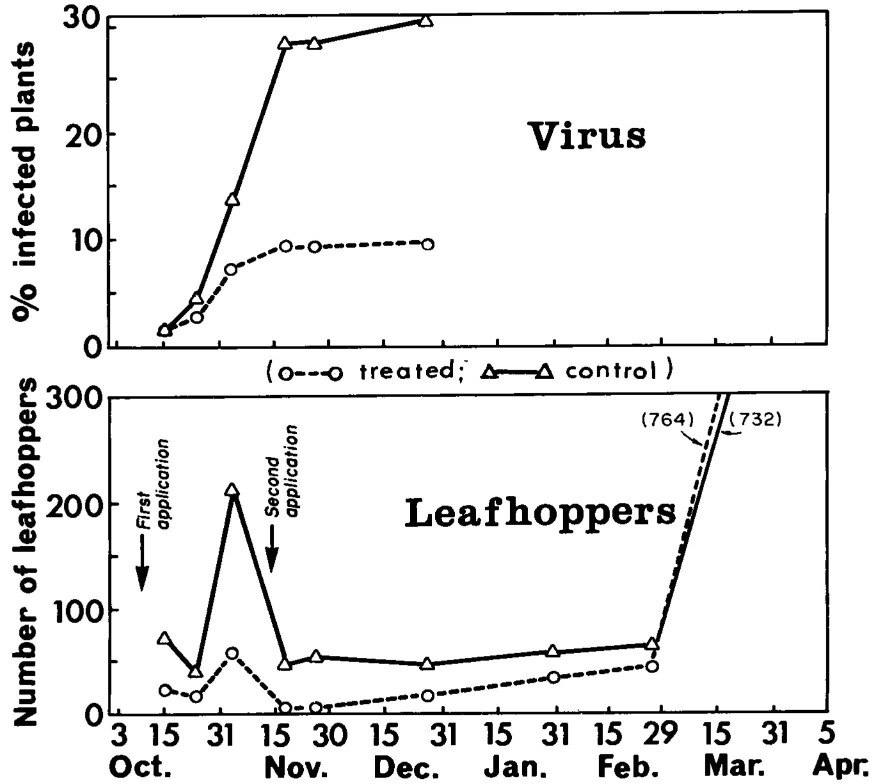
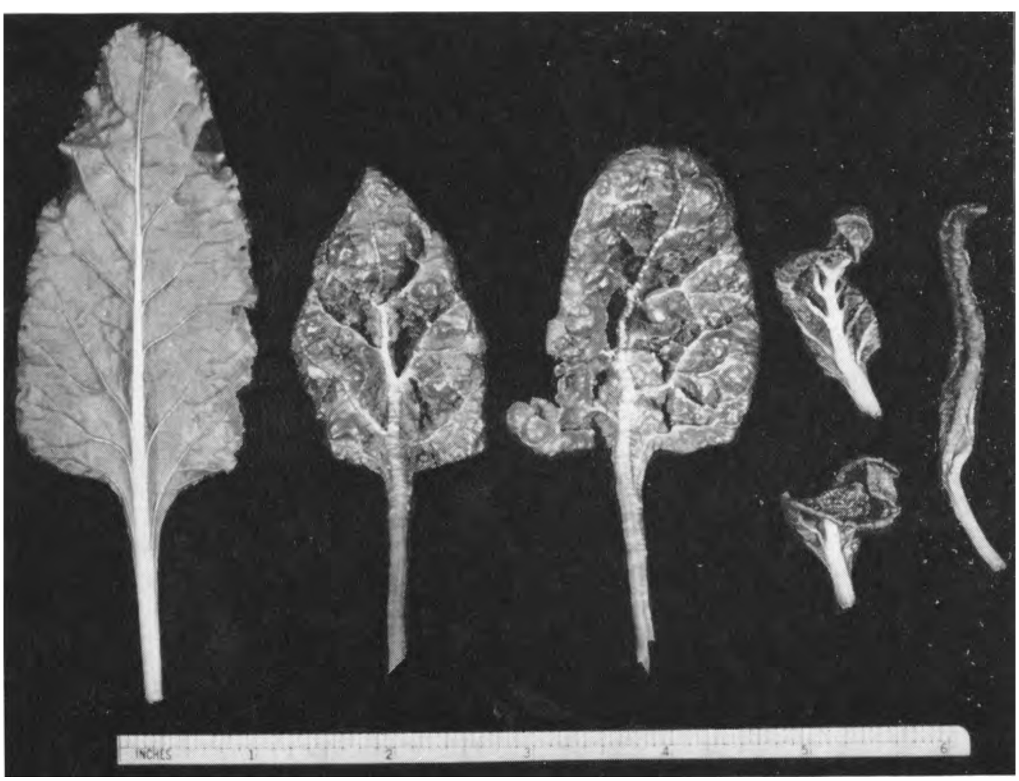
# *Spread of Virus Beets*




BEET LEAFHOPPER POPULATION DENSITY AND INCIDENCE OF CURLY TOP VIRUS IN TREATED AND CONTROL PLOTS

Forty small screen cages, each containing five leafhoppers, were attached to treated plants at various time intervals after application of the insecticide; mortality of these insects and a similar group confined on untreated plants was determined 24 hours later. The results in table 1 show that about 50% of the leafhoppers died within 24 hours, but the toxicity declined considerably by the 27th day; then it rose shortly after application of the second treatment, but declined again markedly 13 days later. Although this type of test provided a general idea of the presence or absence of insecticidal activity in the plants, fluctuations in environmental factors precluded strict comparisons among these figures. It was found, for instance, in greenhouse experiments that temperature has a profound effect on the extent of feeding by the beet leafhopper. Thus, at higher temperatures the insect ingests greater quantities of sap and, therefore, is more likely to be affected by the treatment.

Symptoms of curly top virus infection on sugar beet leaves. Left, a healthy leaf.



## Leafhopper density

Samples of the leafhopper population were taken with a power suction machine from four 50-ft row sections, at three different locations in each plot, thus totaling 600 ft of row per plot. A summary of the effect on population density based on samples collected at different times after treatment is given in table 2 and the graph. The first treatment caused a reduction in the leafhopper population varying from 53 to 73% on the three sampling dates. The second treatment caused a more drastic reduction (over 91%) for at least 13 days. Forty-four days after the second application, the number of leafhoppers in the treated plots was still 60% lower than in the controls. Small-scale tests with caged leafhoppers soon after the second (topical) treatment indicated the presence of fumigant action which had apparently supplemented the systemic activity of the insecticide. This fumigant action appeared to have affected the insect population drastically in the control plots as well.

TABLE 1. MORTALITY OF BEET LEAFHOPPERS CAGED ON PLANTS TREATED WITH THIMET.

| Days after applications | | % mortality in 24-hours* |
|---|---|---|
| No. 1 | No. 2 | |
| 7 | — | 40 |
| 16 | — | 54 |
| 27 | — | 14 |
| 41 | 5 | 36 |
| 49 | 13 | 8 |

* Corrected by Abbott's formula; control mortality less than 5%.

TABLE 2. EFFECT OF THIMET TREATMENTS ON BEET LEAFHOPPER POPULATION DENSITY.

| Days after applications | | Beet leafhoppers sampled | | Leafhopper reduction in treated plots (%) |
|---|---|---|---|---|
| No. 1 | No. 2 | Treated plots | Control plots | |
| 7 | — | 24 | 71 | 66 |
| 16 | — | 19 | 40 | 53 |
| 27 | — | 59 | 219 | 73 |
| 41 | 5 | 3 | 46 | 93 |
| 49 | 13 | 5 | 54 | 91 |
| 80 | 44 | 17 | 43 | 60 |

TABLE 3. EFFECT OF THIMET TREATMENTS ON CONTROL OF TRANSMISSION OF CURLY TOP VIRUS IN SUGAR BEETS.

| Days after applications | | Curly top virus incidence (%) | | Virus reduction in treated plots (%) |
|---|---|---|---|---|
| No. 1 | No. 2 | Treated plots | Control plots | |
| 7 | — | 1.76 | 1.57 | —— |
| 16 | — | 3.06 | 4.63 | 33.91 |
| 27 | — | 7.13 | 13.70 | 47.96 |
| 41 | 5 | 9.63 | 28.15 | 65.79 |
| 49 | 13 | 9.26 | 28.43 | 67.43 |
| 80 | 44 | 9.72 | 30.74 | 68.38 |

The data on curly top virus incidence shown in table 3 and the graph were obtained by carefully examining a total of 1,080 plants from the treated plots and an equal number from the controls on each sampling date. At the time of the last sampling there was an average of 9.72% infected plants in the treatments as compared with 30.74% in the controls —a reduction of 68.38%.

No further counts were taken due to the reduction of insect activity as a result of the onset of cooler temperatures. In addition, the plants had by then reached the stage when they could suffer only negligible damage as a result of further virus infections.

The above results indicate the possibility of substantial reduction in the spread of curly top virus of sugar beets by the use of a systemic insecticide. Further work is now underway to test the efficacy of the treatments under different environmental conditions and in situations of higher vector density.

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# *Gibberellin Sprays Delay Lime Maturity*

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PRELIMINARY TRIALS indicate that gibberellic acid sprays will delay maturity of limes as well as lemons (*California Agriculture*, January, 1964). In southern California, Bearss lime trees bear some fruit most of the year, but much of the crop colors and ripens in the fall and winter and must be picked. As with lemons, the lime industry would benefit if more fruit matured later in the season when the demand is greater.

Other advantages resulting from a delay in maturity for both limes and lemons include: a larger percentage of fruit with a long storage life and a decrease in small tree-ripe fruit. Gibberellic acid also tends to delay the loss of green pigments from other citrus fruits.

Trials to influence fruit set with other growth regulators were conducted in Santa Barbara County in 1958. Giberellin sprays were tested in 1960 in San Diego County. Both of these early trials were inconclusive.

TABLE 1. YIELD OF GIBBERELLIN-SPRAYED LIME TREES (SAN DIEGO, 1963–64)

| Harvest dates | Control | | Gib-sprayed | |
|---|---|---|---|---|
| | Boxes* | Pounds | Boxes | Pounds |
| 11/24/63 | 11.0 | 482 | 9.0 | 388 |
| 12/30/63 | 11.0 | 445 | 15.0 | 585 |
| 2/18/64 | 2.5 | 103 | 4.5 | 191 |
| | 24.5 | 1030 | 28.5 | 1164 |

Sprayed November 8, 1963.
* Total field boxes from 15 trees in each treatment.

The recent series of trials reported here began in November, 1963, with spray applications of 10 ppm gibberellic acid to 15 lime trees in each of two groves. One grove in Orange County included mature, relatively nonvigorous trees approximately 30 years old. The other was a grove of vigorous five-year-old trees in northern San Diego County.

There were only two harvests after spraying on the older grove in Orange County—mid-December and early February 1964. In the first pick, the total box counts for the 15 gibberellin-sprayed trees and 15 unsprayed check trees were almost the same. A total of 10½ boxes were picked from the sprayed trees and 11 boxes for the checks. The second pick at the older grove was 16 boxes for the sprayed trees and 13 for the checks. Total for both picks was 26½ for the gibberellin-sprayed trees and 24 for the control trees.

In the younger grove at Valley Center there were three picks after spraying—November 24, December 30, 1963, and February 18, 1964 (table 1). There was a total of four more boxes picked from the 15 gibberellin-sprayed trees than the

TABLE 2. PACKINGHOUSE RESULTS OF GIBBERELLIN-SPRAYED LIME TREES (ORANGE COUNTY, 1963–64)

| Treatment | Sizes | | | | Total pounds packed | By-products | | Culls | Total pounds | Total % picked |
|---|---|---|---|---|---|---|---|---|---|---|
| | 160 | 265 | 310 | 385 | | Size 500 | Off grade | | | |
| | *Pounds of Fruit | | | | | | | | | |
| Gibberellin | 0 | 5 | 410 | 175 | 590 | 18 | 42 | 15 | 665 | 89 |
| Control | 0 | 5 | 125 | 170 | 300 | 15 | 95 | 0 | 410 | 73 |

Sprayed November 11, 1963; picked February 4, 1964; washed February 10, 1964.
* Total of 15 trees in each treatment.