in an attempt to bracket the optimum time for spraying. Although the trees were rated for injury more than once during the season, only the data collected on August 24 are shown in graph 2. The major objective of this experiment was to determine whether one properly timed application could effectively control the insect for the entire season. The August 24 injury ratings best present these findings, since they were made after insects had completed feeding for the year.

The emulsifiable formulation of methoxychlor used resulted in injury characterized by a yellowing of the elm leaves and premature leaf drop. Because of the chemical injury, it was difficult to exclude personal bias from the injury ratings; for this reason the ratings on methoxychlor are not shown in graph 2.

From graph 2 it is apparent that the severity of beetle injury decreased as the date of spraying progressed from May 15 to July 1, but increased thereafter. Treatments made too early do not appear to leave sufficient residue to last until needed for effective control of the larvae. There may also be insufficient foliage on the trees at that time to allow effective insecticidal deposits. Treatments made too late, on the other hand, do not protect trees from early larval injury. The low level of beetle injury found on the trees treated July 1 show that a single application, properly timed, will effectively control the first generation of insects and will adequately protect the trees from serious injury by the second generation.

In the second test, four different insecticides were applied on June 11. Beetle larvae were present and their feeding damage was beginning to appear. The table presents counts of insects of the first generation made on June 30. At that time there were no statistically significant differences between methoxychlor, carbaryl, and DDT or between DDT and malathion. All treatments, however, were significantly better than the untreated check. In this experiment, methoxychlor again caused injury to the foliage.

The beetle injury ratings on trees in the second test (made on August 24) as shown in graph 3 indicate that carbaryl performed better than any of the other compounds tested. Since these ratings were made after beetle injury had subsided for the season, it is clear that a single application of carbaryl—made after the majority of the eggs had been laid in the spring and at the time the young larvae were beginning to feed—had satisfactorily protected the trees from injury for the entire season.

EVALUATION OF INSECTICIDES FOR CONTROL OF THE ELM LEAF BEETLE. BISHOP, INYO COUNTY, 1964

Material*	Active toxicant in lbs/100 gals.	Average number eggs and larvae per 50 shoots on June 30†
Methoxychlor	1.0	0.25a
Carbaryl (Sevin)	1.0	0.75a
DDT	1.0	5.5 ab
Malathion	1.0	22.0 b
Untreated	--	96.75c

* Sprays applied June 11.
† Means followed by the same letter are not significantly different at the 5% level.

Other considerations

A single spray, applied at the optimum time from the standpoint of insect development, did not prevent all elm leaf beetle damage. However, the feeding of the adults early in the season and the feeding of the newly hatched larvae, were relatively unimportant and did not justify the application of additional sprays. Results of the field experiments indicate that it is both possible and practical to protect individual trees with carbaryl, and that it is not essential that all trees in an area be treated. Only the sprayed trees will be protected, however.

Some variations in insect development occurred from one section of Bishop to another and were believed to influence the proper spraying date. In the first test, where the beetle infestation was not heavy, the optimum time for spraying was near the end of June or the beginning of July. In the second test, where very heavy elm leaf beetle populations were encountered, the proper spraying date was near the middle of June.

Unlike Bishop, some areas of the state have more than two generations of the elm leaf beetle each year. In such areas, it is not known whether a single spray application will adequately control the insect. In some cities in California where carbaryl has been applied to elm trees for the control of other insects, serious spider mite infestations developed on the trees following the spraying. However, this problem was not encountered in the experiments conducted in Bishop.

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Photos of the elm leaf beetle larvae and adults feeding and of the eggs on the underside of a leaf are by L. R. Brown.

Grape leafhopper nymph on grape leaf.

Properly timed applications of Thiodan or Dibrom are currently effective for use in controlling the grape leafhopper. However, the past record of resistance problems that have developed with other insecticides indicates that it is only a question of time until the same difficulties occur with these materials. Saving these insecticides for emergency use, rather than preventive treatment, and further reliance on an integrated control program appears to offer the best solution.

RECOMMENDED INSECTICIDES for control of the grape leafhopper have changed with the development of resistance and the availability of newer materials—in accordance with results from field trials conducted every year since 1952. Before the integrated control project started in 1961, the benefits of insecticide treatment were evaluated by comparing treated and untreated rows at intervals of one and two weeks after application. With the beginning of the project, leafhopper populations were followed for several weeks after application and for the entire season if possible. The

INSECTICIDES

for control of grape leafhopper

F. L. JENSEN · C. D. LYNN · E. M. STAFFORD · H. KIDO

longer-term studies soon showed the advantage of this technique. Some insecticides produced excellent short-term reduction followed by a flareup of population.

Trials

The results of a number of trials conducted in Tulare and Fresno counties have shown that Thiodan or Delnav sprays and Thiodan dusts produced the longest period of leafhopper nymphal reduction. Delnav kills nymphs rather slowly; two to three weeks being required for counts to reach low levels. Unfortunately, the dosage registered for current use of Delnav is too low to give satisfactory control except for early season application. Therefore, Thiodan remains the best choice of an insecticide at the present time.

Under the integrated control concept, allowing natural control factors to operate until the noneconomic treatment level is reached, means that a chemical must always remain available for emergency treatment. Thiodan can be used effectively through July until early August but effectiveness tapers off sometime in August. After this rather indefinite cut-off date, the short-residual material, Dibrom, will usually produce immediate reductions. Populations rebound rapidly following Dibrom applications so that real problems may also result from attempting to obtain late season control.

The late maturing table grape varieties remain attractive to leafhoppers because of their continued growth, and the control of leafhopper infestations may become an acute problem. This continued exposure to leafhoppers also means accumulation of spotting. Thus, without effective fall control, these late table grapes still require a preventive treatment for third-brood control.

Raisin and wine grapes present a much less serious problem. The termination of irrigation and the cessation of growth lead to a vine condition much less attractive to leafhoppers. Not only is the population usually smaller and the vine tolerance much greater, but should late control become necessary, one application of Dibrom is sufficient to knock the population down for all practical purposes.

Second Brood

The relative merits of first- versus second-brood control have been investigated in several cases. Generally, second-brood applications appear preferable, except where first-brood populations are heavy enough to require control. On Thompson seedless used for raisins or wine, first-brood populations of less than 10 nymphs per leaf are regarded as being below the treatment level.

Sprays or dusts may be applied for either first- or second-brood control of wine or raisin grapes. On some table varieties, second-brood sprays may produce scarring or objectionable visible residue. Generally speaking, sprays produce better controls than dusts although dusts are satisfactory in most instances.

Judging by the past record of leafhopper resistance to insecticides, it is only a question of time until the same difficulties arise with the currently employed materials. Saving these insecticides for emergency use, rather than preventive treatment, would presumably extend the useful period of these chemicals.

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