More serious than the grape leafhopper

The variegated leafhopper, shown here emerging from its shed skin, is a more serious pest of grapes than the closely related grape leafhopper. Late-season leaf burn caused by the variegated leafhopper can seriously reduce vineyard yields.

The variegated leafhopper, an increasing pest of grapes

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Since 1980, when the variegated leafhopper was first reported in California's San Joaquin Valley, it has developed into a serious pest of raisin, wine, and table grapes in the lower valley. The variegated leafhopper, *Erythroneura variabilis,* builds up into large populations late in the season, causing fruit spotting on table grapes, threatening long-term reduction in raisin and grape yields as a result of late-season vine defoliation, and causing a nuisance to pickers at harvest. Increased insecticide applications against this leafhopper are also leading to more secondary outbreaks of mite pests.

Before 1980, the variegated leafhopper had been present, at least since the early 1930s, over the Tehachapi Mountains south of Bakersfield in southern California. Its range currently extends to Livingston, about 70 miles north of Fresno, and it is expected soon to reach all areas occupied by the similar but less damaging grape leafhopper, *E. elegantula.*

We are conducting research on the variegated leafhopper with the following goals: (1) to obtain biological information needed for effective monitoring of vineyard populations; (2) to develop guidelines for chemical control; (3) to evaluate the effectiveness of imported natural enemies for a long-term approach to the problem (imported parasites are through the cooperation of Dan Gonzalez, Division of Biological Control, UC Riverside); and (4) to develop a crop-linked predictive model to aid in management of the insect. The research concentrates on: (1) the behavior of variegated leafhopper on the vine, including its distribution pattern during the season, taking into consideration cultivar (Thompson Seedless, Ribiera, and Emperor), rootstock, cover crop, and effect of insecticides; (2) the insect's growth, development, and population dynamics; and (3) the susceptibility of both the grape leafhopper and variegated leafhopper to egg parasitism by *Anagrus epos.*

In this report, we focus on distribution on the vine and parasitism of the variegated leafhopper.

Distribution on the vine

Knowing the distribution patterns can lead to the development of simplified but accurate sampling and prediction methods, a necessary first step for research or implementation programs. These methods will help determine the nature and timing of insecticide applications and should thereby help curtail excessive insecticide use.

Every week from May through October 1984 and 1985, we examined 32 vines, 16 from each of two rootstocks, 2 from each of four replicated single-row blocks for cover-crop and non-cover-crop treatments, at the Kearney Agricultural Center, Parlier. On any one vine, six shoots were examined, three from the north side and three from the south side. On each side, the three shoots examined comprised one originating from the basal or trunk region of the vine, one from the shoulder area (approximately where the canes cross the trellis wire), and one from the terminal canes (the distal one-third of the cane, farthest from the trunk). On each shoot, each leaf was numbered sequentially and the numbers and age classes of variegated and grape leafhopper and various predators were recorded with respect to leaf surface.

Late in the season, we reduced the sampling to every third leaf because of increasing shoot size and number of leaves. To estimate whole-vine population density for each age class and insect species recorded, we made cane and shoot counts each season.

We are presenting a preliminary examination here — that is, a subset of a large data set. Although the results may differ to a degree from those that will come from a complete analysis, certain trends in the data are clear.

With regard to distribution on the shoot, the entire first brood developed within the first three to five leaves down from the cane, or roughly on the basal one-fourth of the shoot (fig. 1). The second and third broods were about equally distributed between basal, mid, and terminal leaves within the shoot. Little difference was apparent in the distribution on leaves within basal, shoulder, and terminal shoots.

Beginning with the second brood, on vines planted east-west, the variegated leafhopper showed a preference for the north-facing aspect; approximately twice the number of leafhopper nymphs per leaf were on the northern as on the southern leaves during the third brood (fig. 2). This observation may indicate that leaf temperature and humidity in the more shaded side are conducive to leafhopper development. Whether this relates more to the quality of egg-laying sites for second-brood adults, or to food quality, or both, remains to be answered.

Distribution results related to rootstock showed major differences in leafhopper populations between the Salt Creek and the Vinifera rootstocks. Vines

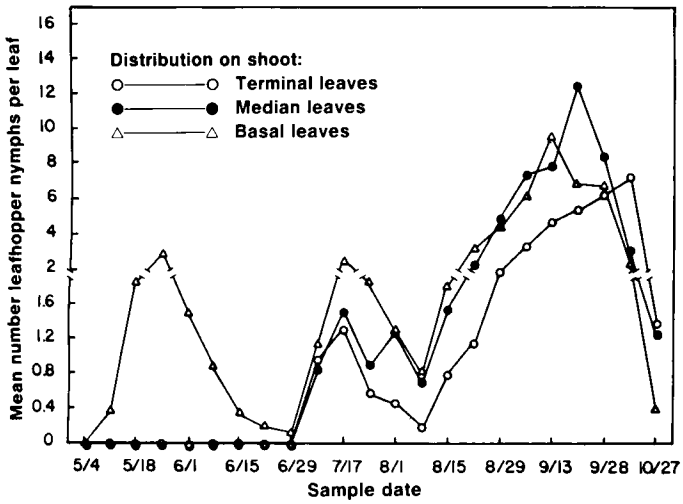

Fig. 1. First-brood variegated leafhopper nymphs were distributed mainly on the basal leaves of the vine shoot. Second and third broods were more evenly distributed on the shoot.

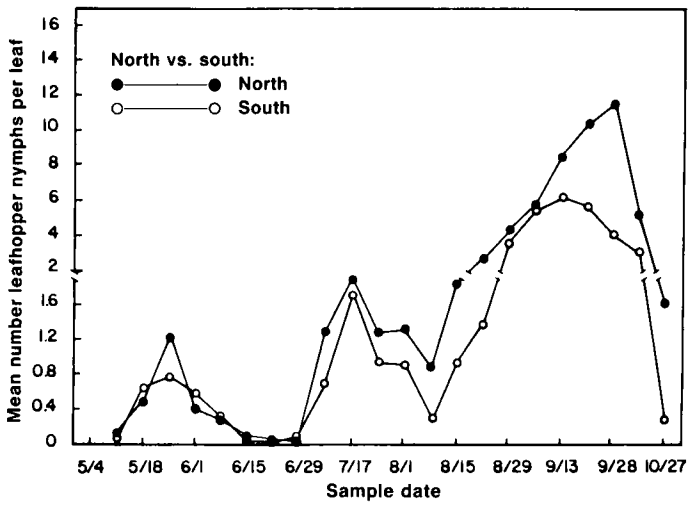

Fig. 2. Variegated leafhoppers showed a preference for the north side of the grapevine, possibly because shade and humidity are conducive to its development.

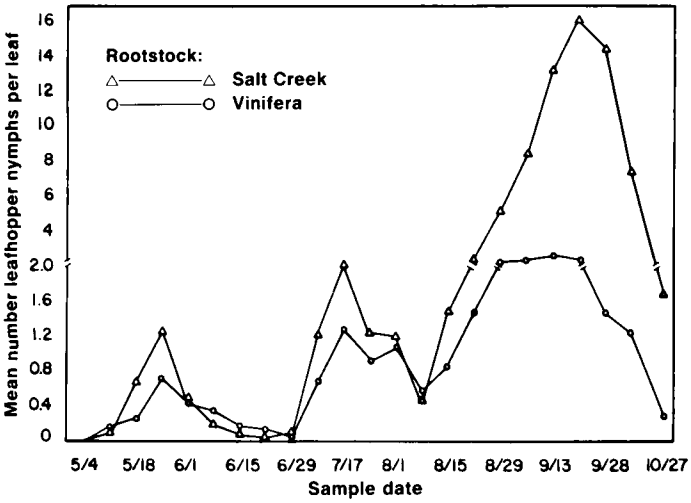

Fig. 3. At the peak of the third brood, vines on Salt Creek rootstock, often used for its lush growth on poor soil, had eight times more variegated leafhopper nymphs than vines on Vinifera.

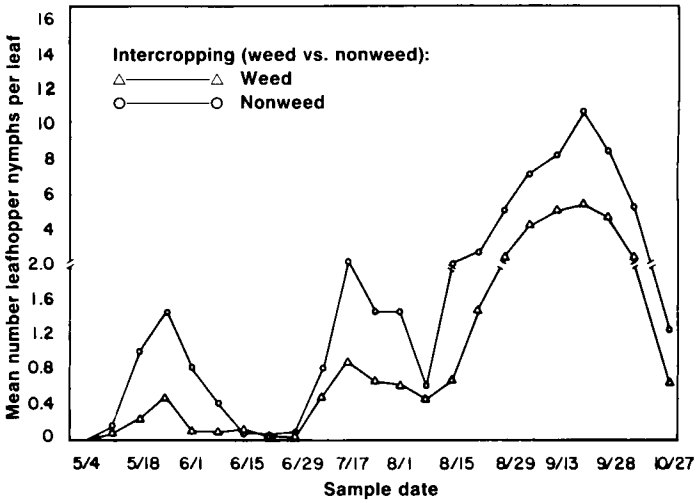

Fig. 4. Leafhopper population differences between cover and noncover plots are clearcut, but the reasons for the differences are not so clear. Cover-crop-based predators may be the answer.

on Salt Creek rootstock, sometimes used on very poor sandy soil for its production of relatively lush growth, had about eight times as many leafhopper nymphs per leaf as those on the Vinifera rootstock at the peak of the third brood (fig. 3).

Leafhopper population differences between cover and noncover plots are clearcut for all three broods (fig. 4), but the reasons behind these differences are not so clear. Anecdotal reports from growers in the area suggest that weedy cover crops in early to mid-season may have smaller populations of leafhoppers. An increase in the abundance of generalist predators, especially spiders, may help reduce leafhopper populations in the weed-cover plots. In other crops, a relationship between increased numbers of beneficial insects and cover crops has been demonstrated.

Leafhopper egg parasitism

Variegated leafhopper is moving into a vineyard system inhabited by the grape leafhopper, a closely related species. The grape leafhopper, an occasionally serious pest in its own right, is often kept under control in San Joaquin Valley Thompson Seedless vineyards by a minute egg parasite, the wasp *Anagrus epos*. Biological control is especially effective on Thompson Seedless.

Results from studies at Kearney Agricultural Center in 1984 show that *Anagrus* parasitizes variegated leafhopper eggs, but at a much lower rate than it does grape leafhopper eggs. Not much larger than a third of a millimeter long, the wasp can be detected by the presence of red leafhopper eggs on leaves, which is the later development of the larval wasp within the egg before emergence of the adult wasp. Many vineyards in the San Joaquin Valley benefit from greater than 90 percent parasitism of grape leafhopper eggs during second and third broods.

One question is why *Anagrus*, known to parasitize about a dozen leafhopper species, is unable to control variegated leafhopper. The answer has to do with a difference in how the two leafhopper species lay eggs in grape leaves. The characteristic blister-like appearance of grape leafhopper eggs on the leaf surface can be easily seen with a dissecting microscope or a hand lens. Variegated leafhopper eggs do not form blisters, but are deeply embedded, and can be seen only with light transmitted from below the leaf.

Detailed examination by paraffin embedded, thin-sectioning techniques verifies that the grape leafhopper egg is inserted just under the epidermal layer of

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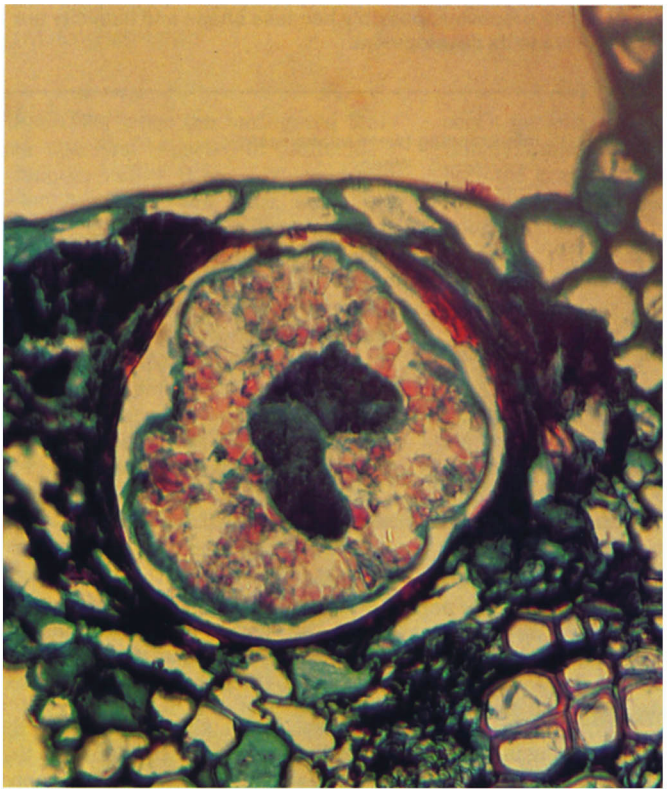

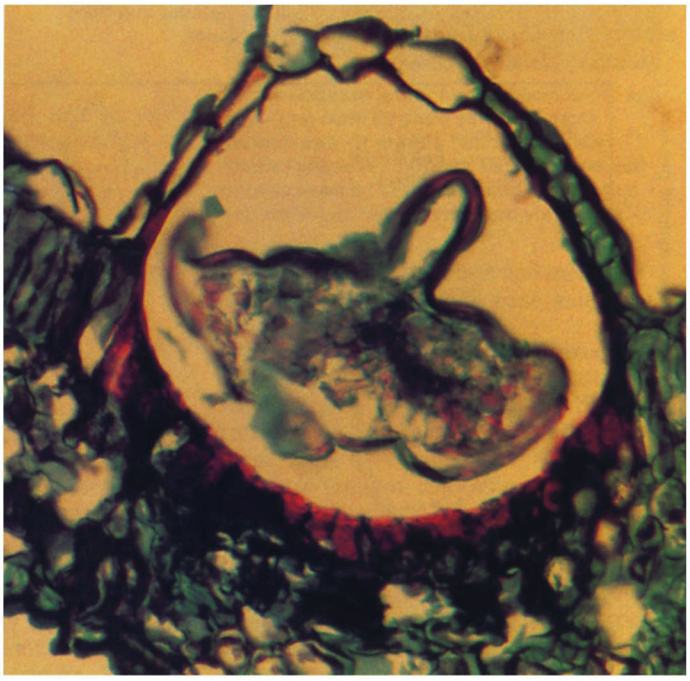

Variegated leafhopper eggs deeply buried in the leaf tissue (left) are less subject to detection by the parasitic wasp *Anagrus epos* than are eggs of the grape leafhopper, which stand out as blisters on the leaf surface (above).

the leaf forming a protruding bump, covered by only one leaf-cell layer. The variegated leafhopper egg is consistently injected deep within the leaf mesophyll or, more often, deep within the tissues surrounding the leaf vascular bundles or veins. Only a relatively small area of a variegated leafhopper egg is within one leaf-cell layer of the surface.

Additional tests and observations on the behavior of the parasite in relation to the two species of leafhopper eggs are under way. Although the wasp's ovipositor is long enough to reach a variegated leafhopper egg from either leaf surface, preliminary results suggest that the wasp is simply not as likely to find a variegated leafhopper egg as a grape leafhopper egg. This possible "refuge" from parasitism may help explain the rapid build-up of variegated leafhopper populations.

Conclusions

Preliminary analysis of research on distribution patterns of variegated leafhopper on the vine shows major population differences related to position of the leaf on the shoot, north and south sides of the vine, rootstock, and cover crop. We will use these results to develop a sampling method as part of an integrated management program.

Variegated leafhopper is a more serious pest than the grape leafhopper, in part because of differences in egg-laying behavior. Variegated leafhopper eggs deeply buried within the leaf tissue are less likely to be detected by *Anagrus epos* than grape leafhopper eggs, which stand out as blisters on the leaf surface. A detailed understanding of factors affecting leafhopper parasitism will provide a framework for evaluating potential new candidates for the biological control of the variegated leafhopper.

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