

Leaf-footed bug implicated in pistachio epicarp lesion

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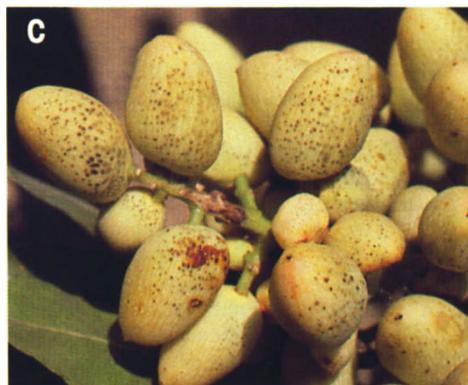
California pistachio production is a fast-developing industry: over 40,000 acres of trees have been planted in the past 12 years. Although a number of disease and insect problems are known to affect pistachios in California, "epicarp" lesion is considered one of the most serious problems, causing losses of 30 percent or more. Although it is termed "epicarp" (skin) lesion, it also affects the mesocarp (flesh), and the endocarp (shell) of the fruit.

The cause of epicarp lesion has eluded scientists for many years. It has been suggested to be a manifestation of scion-rootstock incompatibility. It has also been thought of as a genetic or a physiological disorder, or both. However, none of these suggestions has been supported by sufficient evidence to establish it as the cause. We undertook this study to determine the cause of epicarp lesion in pistachio, *Pistacia vera* L., grown under California conditions.

Symptoms

Epicarp lesion symptoms are variable. For convenience, we have separated them into the following four distinct types, based on our survey during the 1983 growing season: surface lesion (type A), stylar-end lesion (type B), necrotic spots (type C), and internal browning (type D).

Type A: The first symptom of epicarp lesion appears as a light brown diffuse area with dark brown zones on the outer surface of the green fruit, with or without a black spot where the lesion originated. The affected area varies in size but may eventually cover the entire surface. Generally, however, only a portion of the fruit surface is affected. In time, the affected areas become characteristically dark brown to almost black. The lesions are dry, but soft in texture, and they become concave as the underlying tissue shrinks. In many cases, we found exuded resin in the center of the lesion. Affected fruits of the cultivar 'Trabonella' and occasionally those of 'Kerman' dry into hard, brown mummies, which maintain a rough texture and drop. These symptoms may origi-



Four types of epicarp (skin) lesion symptoms: (A) surface lesion, (B) stylar-end lesion, (C) necrotic spots, (D) internal browning. These symptoms may occur at random.

Clusters of 'Kerman' pistachios enclosed in an open-mesh cloth bag with leaf-footed bug for 48 hours developed symptoms of epicarp lesion within a short time (right). Control clusters enclosed in bags without leaf-footed bug were undamaged.

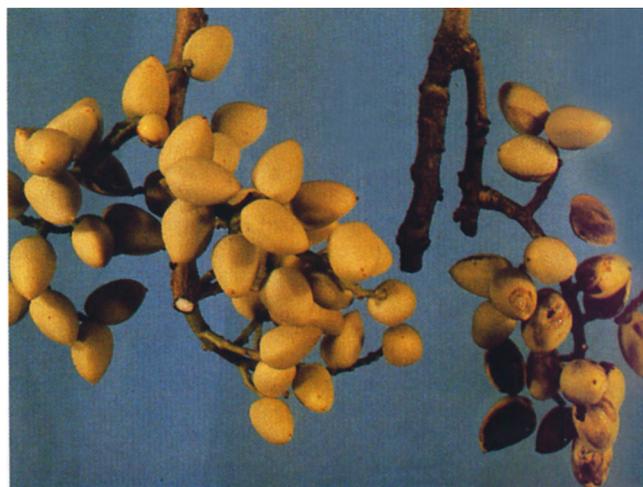


Table 1. Epicarp lesion (EL) development in pistachio fruits of the cultivars Kerman and Trabonella exposed to leaf-footed bug (LFB) on different dates

Treatment	Date of exposure and EL development						Fruits that dropped†
	June 6	June 9	June 21	July 7	July 11	July 20	
Untreated	%	%	%	%	%	%	%
control	5.6	0.0	0.6	0.0	0.0	0.0	3.8
LFB	62.8**	71.8**	32.4**	0.0	0.0	4.3	32.9*

NOTE: Pistachio fruits exposed to LFB for 48 hours beginning on dates indicated; number of fruits that had developed EL recorded on August 5. For each test, a minimum of seven replications (one cluster of nuts/insect/replication) was used.

† Mean percentage of all exposure dates.

* Indicates significant difference from control according to a t-test at $P=0.05$ (*) or $P=0.01$ (**).

Table 2. Epicarp lesion (EL) development in pistachio fruits of cultivar Kerman exposed to different numbers of leaf-footed bugs (LFB)

Number of LFB per cluster	Fruits with EL symptoms	Fruits that dropped
	%	%
Control (no LFB)	0.0	3.3
One LFB	52.2	21.7
Two LFB	76.2	0.0
Four LFB	86.9	13.0

NOTE: Pistachio fruits were exposed to LFB for 48 hours on June 9 and the results recorded on August 5.



Adult leaf-footed bug and its eggs (segmented strip on pistachio nut at right).

nate at random on the fruit, and they were the most common symptoms of epicarp lesion during the 1983 growing season.

Type B: Styler-end lesion originates exclusively on the blossom end of the fruit. A small, dark brown spot develops and then enlarges rapidly to cover most of the fruit. Diffuse brown areas with darker zones are absent, and generally no resin exudation is associated with this lesion. In time, the affected areas become characteristically dark brown in color and dry but soft in texture, as described in type A symptoms. The shell in the affected area fails to harden.

Type C: From 1 to 50 or more, tiny, dark brown, necrotic spots appear on the outer surface (epicarp) of the fruit. Resin occasionally exudes from the spots. Although the dark spots are generally scattered on the surface, sometimes they are only found close to the styler, or blossom, end of the fruit. The necrotic tissue may extend into the flesh, but not the shell.

Type D: Internal browning involves only the flesh and the shell. The epicarp layer maintains its natural green color, but when it is cut away, the flesh and the outer surface of the shell are seen to be dark brown to black.

Symptom types A, B, and C were observed at any time from shortly after fruit set until a month before harvest, but they occurred more frequently before shell hardening. Type D was observed only after shell hardening.

Leaf-footed bug

On May 25, 1983, we found the leaf-footed bug, *Leptoglossus clypealis* L., feeding on pistachio fruits in Kings County. This bug, which is widely distributed and feeds on several field and vegetable crops, has been found in pistachio orchards in Butte, Contra Costa, Fresno, Kern, Kings, Madera, and Solano counties.

We studied the involvement of leaf-footed bug in epicarp lesion in Solano County at the Wolfskill Experimental Orchards of the University of California, Davis, during the 1983 growing season. Leaf-footed bugs collected while feeding on pistachio fruits in Fresno, Kings, and Solano counties were enclosed with healthy-appearing clusters of pistachio fruits in open-mesh cloth bags at different times. Each time, the clusters were exposed to the bugs for 48 hours. Clusters of pistachio fruits similarly enclosed, but without the bugs, served as controls. For each test, we used a minimum of seven replications (one cluster of nuts per insect per replication).

Our studies indicate that epicarp lesion can be caused by feeding injuries of the leaf-footed bug. Symptoms developed within 48 hours after the feeding and were identical to type A symptoms occurring on naturally affected fruits. Exposure of the fruits to leaf-footed bug at different times during their development indicated that pistachios become either less susceptible to feeding injury

by the bug or less prone to symptom expression (table 1). Fruits that developed symptoms ranged from 60 to 70 percent in June to none in July. These results agree with field observations, which indicated that fruits are not likely to develop type A symptoms within a month of maturity. Also, as the number of bugs per cluster increased, the percentage of fruits developing epicarp lesion symptoms also increased (table 2). Fruits affected by epicarp lesion early in their development were more prone to drop than those affected later. This was especially true with 'Trabonella', in which virtually all fruits affected before July had shriveled and dropped from the trees by August 5.

Type B symptoms were not reproduced in these experiments by exposure of pistachio fruits to leaf-footed bug. Type C symptoms were observed only on fruits exposed to the bug on June 21, and type D symptoms, on fruits exposed to the bug in July and August. In these experiments, no necrotic lesions were observed on nut meats with type D symptoms.

Conclusion

These studies demonstrate that leaf-footed bug is undoubtedly involved in the development of epicarp lesion in pistachio fruits. Further research is under way at UC Davis to determine if leaf-footed bug or other insects inject enzymes into the fruit during feeding to induce epicarp lesion, and if water stress in the tree is related to development of type B symptoms. Studies to determine if fungi, bacteria, or yeasts are involved in the disorder are also planned.

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