New clues in understanding Pierce's disease

Paul H. Goodwin ❑ Carole P. Meredith

The discovery that water stress is associated with Pierce's disease may be useful in developing new resistant varieties

Although it is less serious now than it once was, Pierce's disease can totally destroy some vineyards. Severe outbreaks still occur in parts of the Napa and San Joaquin valleys.

Pierce's disease, a lethal disease of grapevines, is found in almost all the major grape-growing regions of California. It was first observed in Anaheim in the 1880s, when it quickly destroyed some 35,000 acres of vines. Since then, there have been several epidemics of the disease, the most severe of which were during the 1930s and '40s in the San Joaquin Valley. The disease causes relatively small losses today, but destruction in some vineyards can approach 100 percent. The most serious outbreaks of the disease now occur in portions of the Napa and San Joaquin valleys, and in southern California.

Pierce's disease is caused by a bacterium, *Xylella fastidiosa*, which lives in the water-conducting system of grapevines and other plants. The bacterium is spread by leafhoppers known as sharpshooters. The blue-green, red-headed, and green sharpshooters (*Graphocephala atropunctata*, *Carneocephala fulgida*, and *Draeculocephala minerva*, respectively) are the most important vectors of the disease in California. When these insects feed on a grapevine, they release the bacteria into the xylem or water-conducting elements of the vine. The bacteria spread inside the vine, gradually killing it by causing plugging of the water-conducting tissue in petioles and leaves.

Symptoms

The symptoms of Pierce's disease are first evident midway through the growing season and become more severe during the fall. For most grape varieties, the most noticeable symptoms are drying or scorching of the leaves. Portions of the leaf margin become yellow and then dry. Leaves of red-fruited varieties usually show some red discoloration. Over a period of days to weeks, successive portions of the leaf turn yellow and then dry, resulting in concentric patterns of dead tissue. These dead portions eventually extend over the entire leaf, which finally falls off with only the petiole remaining attached to the cane. The fruit typically wilts and dries along with the leaves.

Young vines may die within a year from the time of infection, but older vines decline more gradually and can survive for five or more years. If a vine was infected during previous years, scorching is first observed on the oldest leaves on the cane. Farther up the cane, the leaves have less scorching and the youngest leaves do not show any symptoms. Over time, diseased vines become increasingly stunted, having fewer and shorter canes that produce stunted leaves and little usable fruit.

Responses of the vine

Previous research has demonstrated that the water-conducting system of affected vines becomes blocked as symptoms develop. It appears that the leaves scorch because their water supply is disrupted. Other studies have shown that leaves with scorching are highly water-stressed.

Although stressed for water, the scorched leaves do not appear wilted. Grape leaves can respond to a water deficit by closing their stomates, or leaf pores, which reduces the amount of water they lose to the atmosphere and helps to reduce wilting. To study this phenomenon in Pierce's disease, we measured single canes from a diseased and nearby healthy 'Chardonnay' vine for stomatal resistance, transpiration, and photosynthesis at midday (2:00 p.m.).

Stomatal resistance measures the changes in aperture or closure of the sto-

In the first noticeable symptoms of Pierce's disease, portions of the leaf margin turn yellow or red and become dry and scorched (upper left). As the disease progresses, the scorched appearance spreads to the inner portions of the leaf. In the final stages, the dead portions extend across the entire leaf, which eventually falls off. Although the leaves are water-stressed, they do not appear wilted, because they respond to water deficit by closing their pores to conserve moisture.

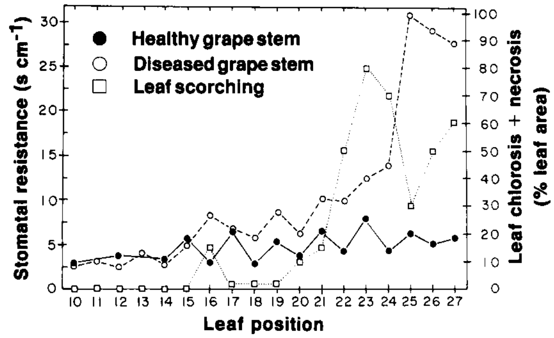

Fig. 1. Leaf pore closure (resistance) was higher on diseased than healthy stem, increasing with scorching of older leaves at positions 16-27 (0=stem apex; 27=base).

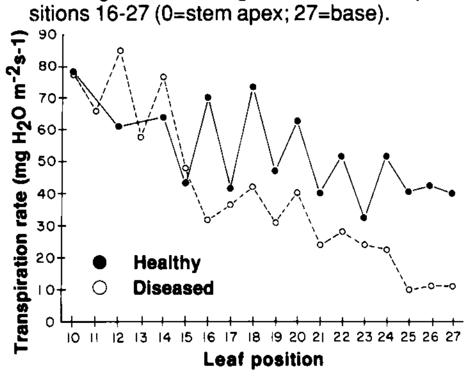

Fig. 2. Water loss (transpiration rate) was lower from diseased than healthy leaves (same stems as in fig. 1).

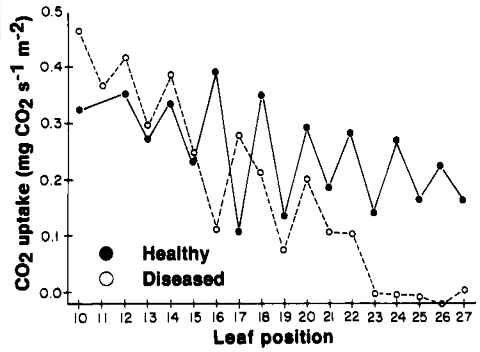

Fig. 3. Photosynthesis (CO_2 uptake) in diseased leaves with severe scorching (positions 23-27) was considerably less than in healthy leaves (same stems as in fig. 1).

mates (fig. 1). For leaves on a healthy cane, stomate closure varied from leaf to leaf but remained relatively low. On a diseased cane, however, older leaves with scorching (positions 16 to 27) had higher stomatal resistances, indicating increased closure of their stomates. Younger diseased leaves without scorching (positions 10 to 15) had stomates more open than those of scorched leaves and were like those of healthy leaves.

The transpiration rate, or rate of water loss from a leaf, shows the effect of stomatal closure (fig. 2). Young leaves (positions 10 to 15) from both healthy and diseased stems had similar transpiration rates. Older diseased leaves with scorching had consistently lower transpiration rates than comparable healthy leaves.

Water stress can adversely affect many leaf functions. One of the most important is photosynthesis, or the production of sugars. The rate of photosynthesis, as measured by the uptake of carbon dioxide (CO_2) by the remaining green areas of the leaf, tended to decline in older leaves of both healthy and diseased vines (fig. 3). But for diseased vines, the older leaves with scorching had much lower rates. Diseased leaves with the most severe scorching (positions 23 to 27) had near zero photosynthetic rates. Those leaves were contributing little or nothing to the growth and maintenance of the vine.

Conclusions

The research results help explain why diseased leaves do not wilt even though their water-conducting system is blocked. As diseased leaves develop scorching, they close their stomates, reducing the amount of water they lose to the atmosphere and partially compensating for the water deficiency associated with the plugging. Diseased leaves, however, are still water-stressed, and functions such as photosynthesis are disrupted. Other detrimental changes in diseased leaves include an imbalance of certain sugars, the loss of chlorophyll, and a disruption of the membranes around the cells. Eventually these changes become so severe that portions of the leaf begin to die and scorching develops. Young symptomless leaves on diseased vines, however, are similar to healthy leaves and have little blockage of their water-conducting system.

The discovery that water stress is associated with Pierce's disease, even though wilting is not observed, provides significant clues in understanding this disease. This knowledge may be useful to researchers in their development of new varieties that are resistant to the effects of the disease.

Paul H. Goodwin is Postgraduate Researcher, Department of Plant Pathology, and Carole P. Meredith is Associate Professor, Department of Viticulture and Enology, University of California, Davis.