Phosphorus deficiency in California vineyards

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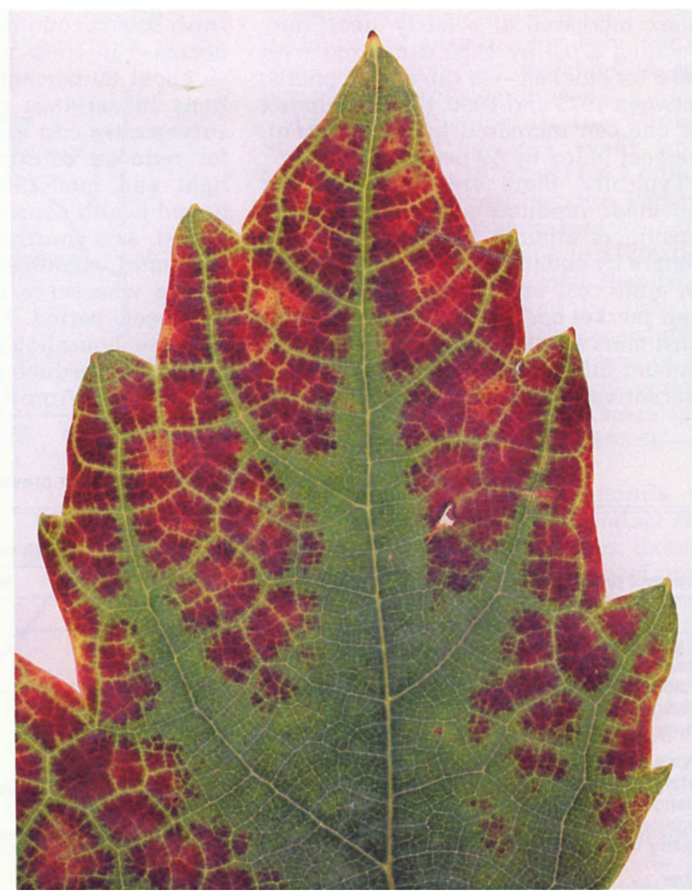
Basal leaves of phosphorus-deficient plants turn yellow in early spring and fall off by bloom time or soon afterwards.

Some higher elevation vineyards respond dramatically to phosphorus fertilizer

California work on phosphorus in vineyards began with W. O. Williams in the 1940s. He conducted numerous trials comparing nitrogen (N) with nitrogen/phosphorus/potassium (NPK) but was unable to find that NPK gave any measurable increase in yield, vine growth, or fruit quality over N alone. Also, he never saw any recognizable symptoms of phosphorus deficiency.

Most of Williams' trials were done on deep valley soils with pH ranges of 6.5 to 7.5. Another University of California, Davis, worker, Lilleland, applied large amounts of phosphorus as triple superphosphate (TSP) to orchards but could not get consistent responses. The orchards were mainly on soils of the Aiken Series. This series and its related phases are California's most notorious soils for "fixing" or inactivating phosphorus. Their high acidity and iron content remove phosphorus by precipitating iron phosphates. These and other

A distinct symptom of phosphorus deficiency is the appearance of red dots on basal leaves, especially on the mid or terminal lobes and at first distant from secondary veins.



The red dots, at first randomly distributed, later line up at right angles to the secondary veins and form dark red bars, which coalesce into islands between green veins.

results led to the conclusion that there was no need to apply phosphorus to either vine or tree crops in California.

The only positive results of phosphorus application to grapes in the world have been obtained by Gärtel and others working in the high acid soils of the Moselle Valley in Western Germany. These steep, hillside soils, mainly of low exchange capacity and low pH values, have produced clear leaf symptoms of phosphorus deficiency. These symptoms have been attributed to the low pH in conjunction with high soil iron and aluminum levels.

Until recently, California growers have avoided using these types of marginal soils. But now, growers are concentrating more on climatic factors and less on potential soil problems. As a result, vineyards are being established at higher elevations on increasingly marginal, shallow, and acidic soils. Hence, more problems of low boron, potassium, magnesium, and, most recently, low phosphorus are appearing.

In the late spring of 1982 our attention was directed to four vineyards in northern California where leaf symptoms and vine behavior suggested phosphorus deficiency. One vineyard was in the eastern hills of the Napa Valley and the other three in the foothills of the Sierra Nevada from Placerville northward to Chico. The affected vines were on the shallow, red, rocky soils of the Aiken Series type. These soils are acidic or slightly so at the surface and are increasingly acidic with depth. For example, the low-phosphorus soil northeast of Chico had a pH of 5.3 to 5.4 in the 0- to 24-inch depth and a pH of 4.4 at 6 feet. The pH at the Napa site was 5.8 to 6.2 at the 2-foot depth.

Leaf and slow-growth symptoms were brought to our attention in the early summer of 1982 at Chappellet Vineyards in eastern Napa County. The leaf symptoms were identical to those previously reported by German workers; several symptoms make up the visual and physical complex, but all are distinct with regard both to leaves and to fruit set. In addition, growth was stunted: by mid-July terminal shoot growth had stopped in the Napa County vineyard now under trial.

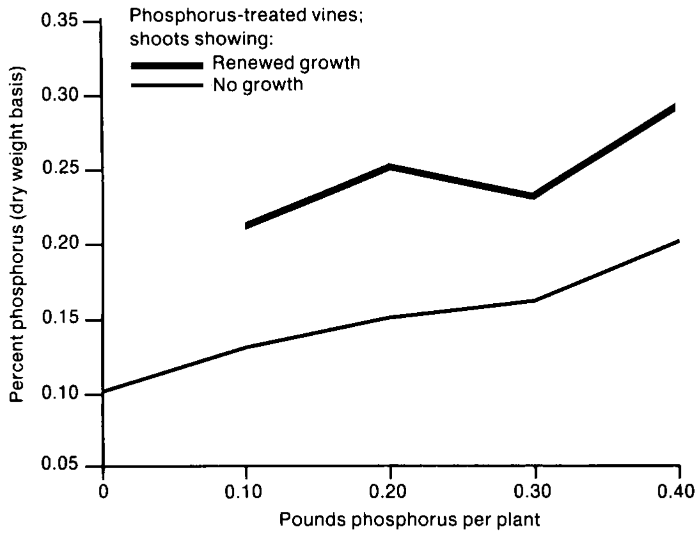
The first foliage tissue samples were taken in mid-July 1982. From these analyses, plus reference to West German literature and photos by Dr. W. Gärtel, the problem was clearly identified.

Total phosphorus in the leaf blade was 0.11 percent, with a petiole phosphorus of 0.04 percent. Normal petiole phosphorus levels in California range from 0.3 to 0.6 percent. In the Placerville and Chico vineyards, petiole phosphorus ranged from 0.07 to 0.14 percent.

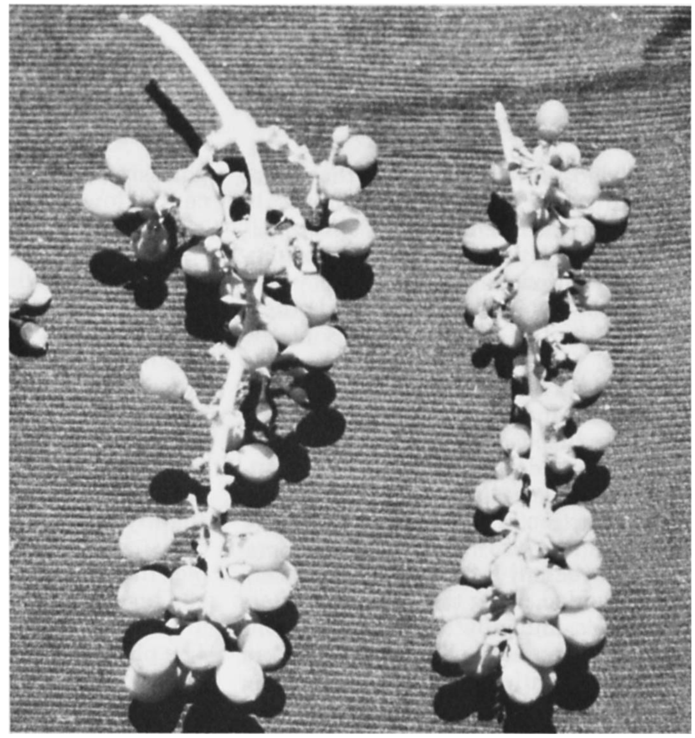
Several phosphate fertilizers are available, but most have the disadvan-

The alignment of red bars at right angles to the veins is a unique and the most distinctive symptom of phosphorus deficiency. Even the smallest veins remain green.

A close-up of the lobes of the grape leaf illustrates the advanced stages of phosphorus deficiency. The dots have coalesced to form vein-delimited islands.



Concentration of phosphorus in shoot tips increased with more applied phosphorus. It was higher in shoots that showed new growth than in those on same vine that did not show new growth.



Shot berries and poor set of phosphorus-deficient Chenin blanc cluster are concentrated at mid-rachis and along the long branch, unlike random pattern of zinc and boron deficiency.

Vines showed rapid new shoot growth with greater internode length within two weeks after addition of phosphorus fertilizer.

tage of low solubility, too much nitrogen, or too much acidity for these already acid soils. To obtain a highly soluble form of phosphate, we diluted 85 percent phosphoric acid in a 300-gallon spray tank and added enough 50 percent sodium hydroxide solution to give a pH of 6.5 to 7.0. One gallon of this mix contained 0.1 pound of actual phosphorus. After a pre-drip irrigation of 24 hours, we put 1, 2, 3, or 4 gallons of the mixture in the drip basins. Irrigation was continued for another 24 hours. There were three replicate rows for each of the first three rates and a single row at 0.4 pound phosphorus. The treatments were applied on August 12.

Within two weeks, shoots on the treated vines showed new rapid growth with increased internode length. Four weeks after treatment some shoots had 20 to 30 inches of new growth. No shoot tips on the untreated vines had resumed growth. On September 14, we took shoot tip samples about 6 inches in length. Since not all shoots on the treated vines had resumed growth, we took separate samples of the non-growth and new-growth tips. Cluster-position leaf blades and petioles were also harvested from untreated rows on both sides and from the middle of the block, as well as from the row that received 0.4 pound.

With increasing amounts of applied phosphorus, the concentration of phosphorus in the shoot tips increased (see graph). However, the shoot tips that showed new growth contained a higher level of phosphorus on the same vines than did those that did not show new growth. There was no change in phosphorus content of petioles from the untreated rows in the two months after the first sampling. However, basal leaves of the vines treated with 0.4 pound phosphorus showed nearly a three-fold increase in petiole phosphorus (from 0.04 to 0.11 percent) and a doubling in leaf blade phosphorus (0.10 to 0.20 percent) in the four weeks after treatment.

This initial experiment shows that correction of phosphorus deficiency is possible. However, until there is much more information available, it is impossible to make specific recommendations. Now that phosphorus-deficient areas have been located and visual symptoms well identified, it will be possible to determine the critical level of petiole phosphorus for normal vine growth as well as any practical yield responses to treatment, and to experiment with other phosphorus materials and methods of application. Several replicated trials were established in 1982, and three more are planned for 1983.

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