

Managing phosphorus deficiency in vineyards

by R. Stanley Grant, Viticulturist, Duarte Nursery, Inc.

In the early 1980s, UC Davis professor James A. Cook and co-workers first observed phosphorus (P) deficiency in California North Coast hillside vineyards and the foothills of the Sierra Nevada.⁶ Affected vines were discovered with stunted shoot growth, poor fruit set, and characteristic leaf symptoms. Research and field experience have since increased our understanding of and ability to manage low levels of phosphorus in vineyards.

Phosphorus deficiency in grapevines inhibits the initiation and maintenance of fruit clusters and flowers within developing buds.¹⁷ As a result, fruit yield from P-deficient grapevines is reduced.^{15,17} Vine growth, whether measured as leaf area, shoot weight, or weight of dormant season prunings, is also reduced by phosphorus deficiency.^{7,15}

Late in the growing season, leaves on the lower part of shoots of severely P-deficient vines develop characteristic symptoms. These include yellow patches between the veins on white fruited varieties and red patches between the veins on red fruited varieties.⁶ Initially the patches are most numerous near the edges of the leaves, but increase in number inward with time. All these effects of phosphorus deficiency are due to disrupted biological processes, including the synthesis of molecules, energy transfer, and photosynthesis.¹⁰

Many California North Coast and

Sierra foothill soils are more highly weathered than in drier portions of California. Weathering occurs when rainwater moves through the soil and removes the components of soluble minerals, including many plant nutrients. In these higher rainfall areas, greater weathering, in combination with the additions of greater quantities of plant matter to the soil, results in soil acidification (pH less than 6.0).

Acid soils are favorable chemical environments for reactions that fix phosphorus, making it unavailable to plants. Grapevine phosphorus deficiency occurs under these conditions.^{1,9,14}

Many acidic soils have phosphorus concentrations lower than 8 ppm by the Bray 1 test. Under these conditions phosphorus deficiency in grapevines is likely to develop. Other methods, such as the Olsen bicarbonate test, are used to evaluate the phosphorus concentration of soils, but the Bray 1 test is the most reliable for acidic soils.

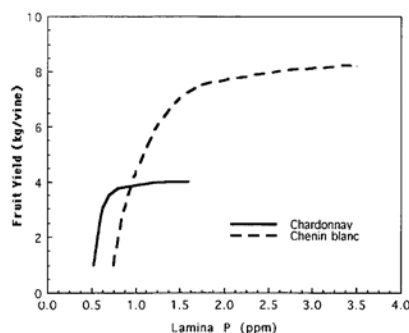
Soil series that include soils of low pH

Table I
Composition of selected phosphorus fertilizer materials.^{3,19}

Fertilizer material	Phosphoric acid analysis (% P ₂ O ₅)	Phosphoric analysis (% P)	Total available phosphorus (%)
Raw rock phosphate	25-41	11-18	14-65
Defluorinated phosphate rock	21	9	85
Magnesium silicate phosphate rock	23	10	85
Phosphoric acid ^z	52-54	23-24	100
Superphosphoric acid ^z	76-83	33-36	100
Single superphosphate	18-20	8-9	97-100
Triple superphosphate	45-46	20	96-99
Monoammonium phosphate ^z	20-61	9-27	100
Diammonium phosphate	46-48	20-21	100
Ammonium phosphate-sulfate	20 or 39	9 or 17	100
Ammonium phosphate-nitrate	12	5	100
Ammonium polyphosphate ^z	35-62	15-27	100
Urea-ammonium phosphate	16-42	7-18	100
Urea phosphate	44	19	-
Monopotassium phosphate ^z	51-52	22-23	100
Dipotassium phosphate	41	18	100
Potassium polyphosphate	51	22	100

^z Some or all fertilizers materials of this type are suitable for drip irrigation. Verify suitability with fertilizer supplier before using.

Figure I
Effect of leaf blade phosphorus concentration on fruit yield for Chardonnay and Chenin blanc grapevines.¹⁵



WINEGROWING

and low phosphorus are the Aiken, Manzanita, Musick, Pentz, Redding, and Sobronte. Grape growers developing vineyards in acidic, low phosphorus soils will likely need to apply fertilizers containing phosphorus.

Fumigation of a low phosphorus soil can increase the difficulty of acquiring phosphorus by grapevines. Most soil fumigants are biocides that indiscriminately kill the living organisms they contact, including mycorrhizae.¹¹ Mycorrhizae are a group of naturally occurring fungi that infect roots, increasing the nutrient-absorbing capabilities of the host plant.¹⁸ Inoculation of young grapevines in fumigated soil with selected mycorrhizae may result in infection and increased vine growth, but introduced fungi are generally not as effective as native fungi and recovery from fumigation is usually not complete.¹⁶

Cook and his co-workers collected petioles from leaves opposite clusters during bloom. They found phosphorus concentrations between 0.04% and

0.07% (400 to 700 ppm).⁶ In California, phosphorus concentrations in petioles during bloom normally range from 0.3% to 0.6%,⁶ and petiole phosphorus concentrations lower than 0.10% (100 ppm) have been considered deficient.⁴ However, recent research indicates that the leaf tissue phosphorus concentration associated with deficiency may vary with scion and rootstock variety.

Ungrafted vines have been shown to generally differ in petiole phosphorus concentrations,^{2,5} and the varieties Chardonnay and Chenin Blanc to differ in the leaf blade phosphorus concentration associated with maximum yield (Fig. 1).¹⁵ Scion and rootstock influence the extent that vine growth and leaf area are inhibited by phosphorus deficiency.⁷

In addition, rootstocks differ in their ability to take up phosphorus from the soil, to translocate phosphorus to the scion, and in their influence on phosphorus use efficiency by the scion.⁸ These observations suggest that a

single leaf tissue phosphorus concentration may not accurately diagnose phosphorus deficiency in all scion-rootstock combinations. Until further research involving several scions, rootstocks, and soil phosphorus levels is conducted, the 0.10% criteria should be used loosely.

Plant nutrients required in large quantities, such as phosphorus, are called macronutrients. Macronutrient deficiencies are usually corrected by applications of fertilizers to the soil. In field trials, applications of phosphorus fertilizer to soils have successfully corrected phosphorus deficiencies.^{6,15} Fertilizer was placed on the soil under the drip emitters by hand. Maximum fruit yields were achieved at 0.3 to 0.4-lb phosphorus per vine for vineyards with conventional vine densities.¹⁵ The beneficial effects of the fertilizer declines with time and reapplication becomes necessary after two or three years.

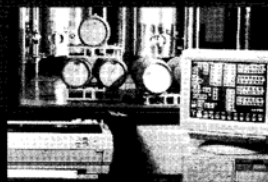
Triple superphosphate and monoammonium phosphate, two commonly

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used phosphorus fertilizers, were used in the trials.¹⁵ There was evidence in this and other studies that the nitrogen present in the monoammonium phosphate fertilizer enhanced phosphorus uptake and utilization by P-deficient plants.¹⁹

The application rates for phosphorus fertilizers are relatively high compared to those used for other macronutrients such as nitrogen. Such high rates are necessary because low pH, P-deficient soils adsorb or fix large quantities of phosphorus. This makes it necessary to apply P-fertilizer in a concentrated band or spot in order to overwhelm the soil's adsorption capacity leaving some phosphorus available to the vines. With lower rates or broadcast applications, most of the applied phosphorus is adsorbed by the soils and not enough is left for the vines.

Lower application rates are required when correcting P deficiency with soluble phosphorus fertilizer applied through a drip system.^{12,13} Savings will

be realized both in the quantity of phosphorus fertilizer applied and the labor required for application.

Fertilizer may be applied through a drip system at any time during the season until leaf fall, but is probably most effectively applied during the spring and autumn while roots are rapidly growing.

It is essential that only soluble phosphorus fertilizers be applied and that only very low concentrations of calcium and magnesium be present in the water flowing through a drip system while phosphorus is being injected to avoid emitter clogging. When their concentrations are sufficiently high, calcium and magnesium combine with phosphorus to form the solid compounds calcium phosphate and magnesium phosphate. Precipitation of these compounds can be avoided by acidifying the irrigation water, which is accomplished through injection of acidic fertilizer or simultaneous injection of acid and fertilizer.

Many growers inject sufficient acid to lower the irrigation water pH between 5.5 to 6.0. Fertilizer is normally applied during the middle of an irrigation set to allow prewetting of the soil prior to the application and flushing of the drip system following the application.

Rock phosphate, the raw material from which commercial phosphorus fertilizers are made, is commonly used by organic growers to correct phosphorus deficiencies because other fertilizers accepted by organic certifying organizations contain much less phosphorus. (Examples of other phosphorus-containing fertilizers accepted by organic-certifying organizations include compost, bone meal, and kelp-based fertilizers.)

Rock phosphate will not be effective in correcting phosphorus deficiencies if it dissolves too slowly, allowing much of the phosphorus to be adsorbed by the soil and leaving little phosphorus for the vines.

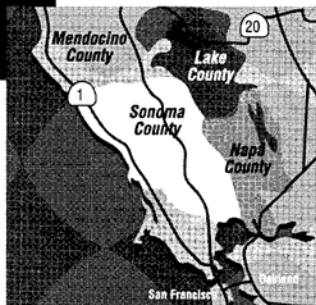
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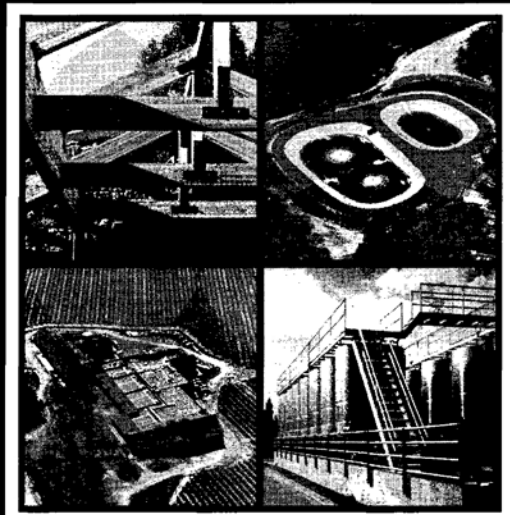
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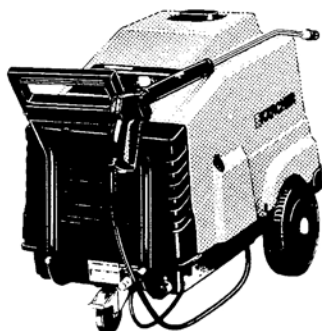
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from apatitic phosphate rocks containing a high percentage phosphorus (see Table I), finely ground, and applied at very high rates (two to three times higher phosphorus rates than conventional phosphorus fertilizer) in a concentrated band or spot.¹⁹ Rock phosphate has the disadvantages of uncertain effective phosphorus concentration and rate of release, and the inconvenience of greater bulk and dust compared with conventional phosphorus fertilizers.

Regardless of the type of phosphorus fertilizer, it is beneficial to apply it to low-P soils in advance of planting a new vineyard to allow it time to saturate the soil's P-adsorption capacity and become available for vine uptake. This is most easily accomplished by shanking dry fertilizer adjacent to the vine row or injecting liquid fertilizer through the drip system. Hand application in the planting hole is more costly and may result in young, tender vine tissues coming into direct contact with concentrated fertilizer. ■

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