California Research

Potassium–Water Relationships in Winegrape Production

By Mark A. Matthews and Mike M. Anderson

Winegrape production is dependent on ample availability of both potassium (K) and water. Management of these two factors becomes especially critical beginning with fruit ripening late in the season because the fruit itself is a large K sink. Research in the North Coast region of California is studying the interrelationship between K fertilization and irrigation management.

GROWERS easily recognize yellowing between the veins and browning of leaf edges as symptoms of K deficiency in grapes. Often, deficiency symptoms appear late in the season, after onset of fruit ripening (veraison). This is well after the usual bloomtime sampling of leaf petioles routinely used for determining vine nutrient status and fertilizer needs. In severe cases, vines may lose a large portion of their leaves, causing delayed fruit ripening. During the recent drought years in California, reports of K deficiency symptoms have increased. This resurrects questions regarding the identification of K deficiencies and the K requirements for production and winegrape quality.

Potassium Deficiency

What determines whether a vine is adequately supplied with K? Grapevine K status is determined by both plant and soil factors, but only soil factors have received researchers' attention. Differences among viticultural regions or vineyards in either set of factors may be important in identifying and correcting K deficiencies. Potassium deficiencies occur more often on sandy soils than on soils with moderate to high clay content. Accordingly, much of the research used to establish criteria for K requirements of grapevines has been conducted on light soils prone to K deficiency, such as in California's San Joaquin Valley. Because the drought seemed to be correlated with increased reports of K deficiency in vineyards on heavier soils in the North Coast region of California, we have been investigating possible regional differences in soil, water and vine characteristics that may be important in vineyard K nutrition. We have found that selection of rootstock and management of soil water content can be important factors.

Potassium Fertilization

When K fertilizer is applied to the soil to increase K supply to vine roots, part of the added K increases the concentration of K in the soil solution, part is adsorbed onto the exchange sites of clay particles and part may be incorporated into nonexchangeable (fixed) forms that return slowly to the soil solution. Thus, the propensity of some soils to replenish the K taken out of the soil solution by vine roots can be low, leading to a decreasing availability of K as the season progresses. This may be one factor contributing to late season K deficiency symptoms on heavier soils. Also, soils with higher fractions of K-fixing clays like vermiculite or with high exchangeable magnesium (Mg) may require higher rates of fertilizer K than indicated by recommendations generated from research on lighter San Joaquin Valley soils in order to get the same increase in K concentration in the soil solution and in K uptake by the vines.

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Potassium Availability and Water

Potassium availability is sensitive to soil water conditions. When irrigation regimes do not resupply the water extracted by the vines and as soil water content decreases, certain clays, e.g., montmorillonite, contract and trap K ions in the interlayers of the clay lattice. This can contribute to late season K deficiency in several ways. On soils with significant amounts of contracting (i.e., shrink-swell) clays, K deficiencies may not occur early in the season when soil water contents are high from winter rains. However, if the soil becomes increasingly dry, K availability diminishes. Deficiency symptoms then develop, especially later in the season when full canopies extract soil water more rapidly than early in the season.

Potassium deficiency symptoms may appear after veraison in vineyards that might produce adequate (or nearly so) tissue K concentrations from samples taken at bloom. Where the drought has decreased the soil water supply available at the beginning of the season, a failure to compensate with more irrigation water can lead to greater soil water deficits than vines had experienced in wetter years. The drier soil again diminishes K availability, inducing K deficiencies in vineyards that previously showed no symptoms. For similar reasons, deficit irrigation for canopy management and to control yield and fruit composition is another potential factor in the appearance of late season K deficiencies.

Recent Studies

Recently, a field study was conducted in a commercial North Coast vineyard of Pinot noir (St. George rootstock) on a clay loam soil. It was an initial evaluation of the role of soil water status in vine K uptake on heavier soils. Treatments of potassium sulphate (K_2SO_4) at a rate of 8 lb/vine were applied to the soil beneath each drip irrigation emitter. Some vines received the standard 10 gal of water/vine/week and others received supplemental irrigation at 40 gal/vine/week.

The vineyard exhibited low available soil K, approximately 130 parts per million (ppm) exchangeable K and low petiole K initially (less than 1 percent of bloomtime dry weight). Petiole K decreased throughout the season for untreated vines to about 0.2 percent K at harvest (**Table 1**). Maintenance of high soil water content under supplemental irrigation increased the availability of K to both K-treated and untreated vines. For untreated vines, petiole K was greater than 0.5 percent at harvest. For K-treated vines that received supplemental irrigation, petiole K actually **increased** during the season. The large differences (several-fold) in vine K status during fruit ripening were associated with smaller differences in juice K and no significant differences in sugar accumulation, pH or acidity of the harvested fruit. Thus, the soil water content during fruit ripening can be an important factor in maintaining canopy K status.

Table 1. Potassium content of petioles and fruit for different K and irrigation treatments for the 1990 season.

	Petiole K, % dry wt.		Juice K, ppm
	Bloom	Harvest	
Standard irrigation			
−K	0.71 ± 0.04	0.24 ± 0.02	1,550 ± 48
+K	0.82 ± 0.11	0.58 ± 0.12	1,691 ± 134
Supplemental irrigation			
−K	0.80 ± 0.11	0.51 ± 0.06	1,673 ± 55
+K	0.90 ± 0.06	1.23 ± 0.12	1,759 ± 47

± standard error.

Plant factors of vine K nutrition include rootstock and scion variety and crop load. Because the fruit constitutes a large K sink, the requirement for K increases later in the season. Scion varieties differ in their requirements for some nutrients, but little research on K nutrition has been conducted on vinegrape varieties. The criteria for K sufficiency in bloomtime petioles were derived from extensive research with Thompson Seedless table grapes. It is not clear whether these criteria are accurate

POTASSIUM deficiency appears on grape leaves and clusters in a rootstock research study.

for winegrape varieties. There is increasing evidence from studies around the world that rootstocks differ in their capacity for nutrient (including K) uptake and that there may be specific rootstock-scion interactions that contribute to vine growth and productivity.

In another field study, the potential to use rootstocks to combat low soil K availability was pursued in an established rootstock trial where vines were exhibiting K deficiency symptoms. The rootstocks 110R, 5C, AxR#1, St. George, and 1202 were investigated to determine whether they caused differences in the K status, fruitfulness and yield of Chardonnay vines growing on a soil with low K availability. Over two seasons the K in bloom petioles was more than two times greater in 5C than 110R. One year after K fertilizer was applied (8 lb K_2SO_4/vine), yield and clusters/vine increased (up to 60 percent) for all rootstocks except 5C, **Table 2**. The high yield, high petiole K and lack of a yield response to applied K on vines on 5C suggest that 5C is more effective at absorbing K from this soil. The results show that there are significant differences among rootstocks in K uptake and in the productivity of the scion at a given petiole K status.

Table 2. Potassium affects yield of Chardonnay grown on different rootstocks for the 1990 season.

	Yield, tons/A		Clusters/vine	
Rootstock	**+K**	**−K**	**+K**	**−K**
110R	5.9 ± 0.2	3.6 ± 0.3	66 ± 4	45 ± 3
5C	5.3 ± 0.7	5.1 ± 0.4	59 ± 7	58 ± 5
AxR#1	6.2 ± 0.5	4.5 ± 0.3	68 ± 3	56 ± 5
St. George	3.1 ± 0.3	2.3 ± 0.3	42 ± 4	32 ± 2
1202	6.3 ± 0.4	4.9 ± 0.4	69 ± 4	55 ± 5

± standard error.

Summary

For existing suspect vineyards, sampling and analysis of vineyard K status and soil water status at or after veraison may be important tools for management decisions. For future plantings, more knowledge of the physiological differences among varieties and rootstocks is needed. Because rootstocks arise from several different species, the probability of significant differences in several aspects of growth and nutrition is high. We anticipate that assays for K status, including the new and sensitive putrescine screening technique, will be tailored to specific varieties and variety-rootstock combinations as more is learned about the nutritional requirements of winegrape varieties and rootstocks. ■