Potassium Status and Soil Water Content of Grapevines on Fine Textured Soils

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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 those light soils, common to California's San Joaquin Valley. Yet, K deficiencies also occur on heavier soils of the North Coast region where there is significant premium winegrape production, but where there has been little or no research on K nutrition for over 50 years.

Irrigation has for some time been known to influence the K status of grapevines. Irrigation regimes may also differ among viticulture regions. Therefore, we have been investigating soil, water and vine characteristics that may be important in vineyard K nutrition in the North Coast.

> Supplemental irrigation above the standard practice maintained high soil water content (SWC) in the rooting zone and increased both the uptake of applied and indigenous soil potassium (K). The benefit of increased K uptake late in one season was apparent in vine K status early in the subsequent season. Applying 8 lb of potassium sulfate (K_2SO_4) per vine under the drip emitter of both irrigation regimes resulted in movement of significant K to a depth of 36 inches in this clay loam soil.

California Studies

Experiments were conducted in a commercial vineyard which had been planted in 1977 to grapevine, *Vitis vinifera* cv. Pinot noir (Gamay beaujaolais clone) on *Vitis rupestris* cv. St. George rootstock on a gravelly clay loam (Haire series). This experiment was designed as a 2 by 2 factorial with rates of irrigation and K_2SO_4 fertilizer as factors and five replications. The two rates of K_2SO_4 were zero (control) and 8 lb/vine. Fertilizer was applied in the spring of 1988 by shoveling it into the drip irrigation basin next to the vine. Two rates of drip irrigation were begun in 1989: 10 gal/vine/week (standard irrigation:STD) and 40 gal/vine/week (supplemental irrigation: SUPP) applied one day each week. Irrigation was begun 2 weeks after bloom and discontinued 2 weeks prior to harvest. (See **Table 1** for specific treatment combinations).

Soil samples were taken from depths of 0-12, 12-24 and 24-36 inches in the spring of 1988 and again after harvest in 1989. The SWC was monitored during 1989 and 1990 using a neutron probe. Access tubes were installed at distances of 8, 30 and 60 inches from a representative vine in each irrigation treatment perpendicular to the vine row. Moisture readings were taken at intervals of 2 inches to a depth of 48 inches.

The cation exchange capacity (CEC)

TABLE 1. Specific treatment combinations included.

K_2O fertilization level	Irrigation level	Code
0 lb/vine	Standard	0-STD
8 lb/vine	Standard	K-STD
0 lb/vine	Supplemental	0-SUPP
8 lb/vine	Supplemental	K-SUPP

This Vineyard is in the North Coast area of California, where premium winegrapes are grown.

of the soil was above 20 meq/100 g to a depth of 24 inches, and 16.7 meq/100 g below that. X-ray diffraction analysis indicated that the clays are composed of smectite, kaolinite, and vermiculite. The presence of both smectite and vermiculite indicated that K fixation could be a concern. One of the consequences of such fixation is a reduced infiltration of K fertilizers into the soils profile. This can be a problem with deep rooted crops, such as prunes or grapes, where high doses of K fertilizers have normally been recommended to overcome high K fixation. It is estimated that 1,070 lb K/A could potentially be fixed by a soil with 1 percent vermiculite and a CEC of 15.4 meq/100 g. This would be equivalent to 3.5 lb K_2SO_4/vine, or 40 percent of the applied K at the vine spacing (6.5 x 10 ft.) in this trial.

Soil K Status. The exchangeable soil K was initially between 100 and 200 parts per million (ppm) and decreased with depth (**Table 2**). During the experiment the exchangeable K in the drip zone (nearest to the vine) of the non-fertilized plots (0-STD and 0-SUPP) decreased at all depths by about 30 percent, indicating that periodic K applications are needed to maintain K availability in this soil type. The K in the drip zone was greatly increased to a depth of 36 inches with application of K_2SO_4 under both STD and SUPP irrigation treatments. Possible leaching of some K below the root zone was not investigated but may have occurred with the high rate of water applied in the SUPP irrigation treatment. The K in the top 12 inches was substantially lower in K-SUPP compared to K-STD (**Table 2**).

Soil Water Status. With SUPP irrigation, SWC next to the vine row and 30 inches away was maintained higher to a depth of 48 inches. At a distance of 60 inches from the row, SWC was depleted during the season similarly under both irrigation rates, indicating that the lateral movement of the water applied through the drip system did not reach the middle of the rows. The depletion value for SWC during the season indicated that the majority of water uptake occurred between 12 and 36 inches for both water treatments.

The rootstock variety (Rupestris St. George) is vigorous, deep rooted, and has

TABLE 2. Exchangeable soil K (ppm) in drip zone before and two years after fertilization with potassium sulfate.

Depth, inches	Initial sample Spring 1988	Sample in Fall 1989, 0 STD	0 SUPP	8 STD	8 SUPP
	ppm exchangeable K				
0 to 12	199	129	131	4,430	1,270
12 to 24	148	83	71	1,910	1,130
24 to 36	101	50	46	730	630

a high root density. The effective rooting depth for all treatments was approximately 48 inches and there were no significant differences among treatments in the total number of root intercepts measured at any depth.

VINE K STATUS. Vine K status (percent K in petioles) was not affected by applied K during the first year (1988) under STD irrigation practices. Complete correction of K deficiency (leaf symptoms, petiole K, yield etc.) in grapevines, even with large K doses such as those in this trial, often does not occur until the second or third season after application. There were also no appreciable differences in K status at bloom in 1989 (**Figure 1**). Vine K status declined throughout the postbloom 1989 season in 0-STD vines. The concentration of K in the petioles is usually highest at bloom, followed by a decrease between bloom and veraison. The decrease was avoided, however, in vines that had K applied such that by veraison the concentration of petiole K was significantly higher for fertilized vines under both STD and SUPP irrigation.

In 1990, the petiole K at bloom was significantly higher in the K-SUPP, K-STD, and 0-SUPP treatments than in the 0-STD treatment (**Figure 1**). This was due to differences in vine K status established by harvest of 1989 since irrigation was not begun until two weeks after bloom in both years. This carry-over effect could be attributed to an increase in root growth due to K application, which was not obvious here, or to increased K stored in permanent parts of the vine.

Petiole K concentration in 1990 declined for all treatments between bloom and the onset of veraison in 1990. Petiole K differences between STD and SUPP treatments once again indicated that the uptake of K was increased at higher soil water content. Also, the application of K maintained petiole K at veraison (both in 1989 and 1990) closer to bloom time levels, and supplemental irrigation further increased K status of fertilized vines.

YIELD. There were no significant yield increases due to K applications in any year. The lack of a positive yield response for vines with bloom petiole K below 1 percent (the established critical level in the San Joaquin Valley) has implications

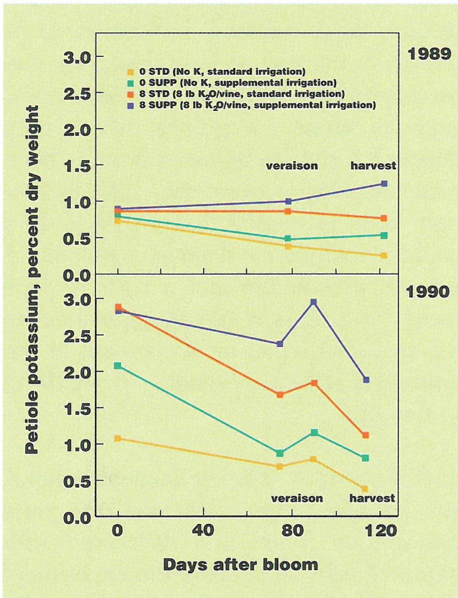

Figure 1. Fertilizer K and supplemental irrigation improve K nutrition of grapevines.

for the critical levels used to evaluate winegrape nutrient status. The failure to obtain increased yields on vines that were clearly K deficient by existing criteria and that greatly increased K status following treatments raises at least two questions that require further study. First, the extent of genetic differences in vine K requirements needs to be better established. There is also evidence of differences in petiole K concentration and yield response to K among rootstocks (see *Better Crops*, Winter 1992-93, pp. 19-21). In a separate experiment, Chardonnay grapes on St. George rootstock (used in this experiment) responded poorly to K fertilization.

Second, the standard of K status, bloomtime petiole K of basal leaves, may not give accurate estimates for some genotypes or growing conditions. If K deficiencies develop later than bloom due to soil drying and K fixation on certain clay soils, for example, the standard sampling approach may not detect the ensuing deficiency.

Summary

Supplemental irrigation above the STD practice maintained high SWC in the rooting zone and increased both the uptake of applied and indigenous soil K. The benefit of increased K uptake late in one season was apparent in vine K status early in the subsequent season.

Potassium fixation may be a concern on many North Coast soils such as at this site with K fixing clays, but the application of 8 lb K_2SO_4 under the drip emitter resulted in movement of significant K to a depth of at least 36 inches under both irrigation regimes. Significant differences in root distribution caused by irrigation and K fertilizer treatments were not detected. About 75 to 80 percent of the root intercepts were encountered at the top 36 inches of the soil in all treatments.

Although bloom petiole K of 0-STD (control) grapevines was near the previous established critical level of 1.0 percent dry weight, the application of K did not significantly increase yields one, two, or three years after applications. Further studies to evaluate the role of varieties and rootstocks relative to yield responses and in interpretation of petiole values is recommended. BC

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