

EFFECT OF IRRIGATION, FRUIT LOAD, AND POTASSIUM FERTILIZATION ON YIELD, QUALITY, AND PETIOLE ANALYSIS OF CONCORD (*Vitis labrusca* L.) GRAPES.

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A 14-year-old Concord vineyard which had received no potassium fertilization since establishment was fertilized with 0 or 450 kg/ha of K under two irrigation and two fruit load regimes. Supplemental irrigation from bloom to veraison increased yields and vine size. Juice soluble solids were reduced by irrigation in a year with near normal rainfall; but in a year of severe drought, soluble solids were improved by irrigation. Increased fruit loads reduced juice quality. Vines receiving K fertilization showed a response the first year of application through increased yields and vine size. Juice pH and K content were increased by K fertilization.

Many preharvest cultural factors can affect quality of grapes through influence on rate of fruit maturation. Irrigation, which increases fruit yield and vine size (5,18,20,21), generally delays fruit maturation (10,21), resulting in reduced soluble solids and pH and higher acidity at the time of a normal harvest. Increasing the fruit load by retaining more fruiting nodes per vine retards fruit maturation and lowers fruit quality (6,11,15,16,21).

K fertilization in the presence of a deficiency will increase fruit yields, while excess K has little influence on yield (8,13,19,23). To correct a deficiency, established at near 1.0 % or below on a petiolar dry weight basis (2,12,13,19), large applications of K have been recommended (7). However, large applications of K to Concord vineyards with no K deficiency have detrimental effects on juice parameters of pH, acidity, and color (17), and the relationship between juice and wine K content., pH and acidity have been examined (3,4,14,17).

The pH and total acidity of both wine and juice products from *Vitis* species have been receiving much attention due to product instability problems associated with these quality parameters. High pH and low acidity adversely affects color of Concord grape juice (17) and red wines (9,22,24), and renders fermented products susceptible to microbial spoilage and reducing shelf life (1).

The purpose of this study was to determine the effects of irrigation, fruit load, and K fertilization on yield, vine size and quality of juice from a mature Concord vineyard which had received no K since its establishment.

MATERIALS AND METHODS

The study was conducted for two years (1979-1980) in an own-rooted Concord vineyard established at the University of Arkansas Agricultural Experiment Station, Fayetteville. Soil was a Taloka Mounded series having a field capacity of 17.1% and a wilting percentage of 5.2. The vines were spaced 2.4 m within the row and 3.0 m between rows and trained to a 1.8 m high Geneva Double Curtain system. All vines were shoot positioned (current season's growth manually positioned vertically toward the vineyard floor) immediately after bloom and two more times at approximately 3-week intervals each year. The vineyard had received no potassium fertilization since it was established in 1966.

Irrigation and fruit load treatments used in this study were established in 1974 and maintained prior to this experiment. Irrigated plots were watered as needed from bloom until near veraison to maintain soil moisture tension between 100-200 mb at a depth of 60 cm. Soil moisture tension in nonirrigated plots ranged from 750-800 mb at 60 cm. Water was supplied to each vine by two trickle emitters placed within the row 60 cm on either side of the trunk. Irrigated vines received 67.2 and 94.1 cm of water/ha (10.7 and 15.0 acre-inches) in 1979 and 1980, respectively. The 20-year average annual rainfall for northwest Arkansas is 95 cm. The annual rainfall for 1979 and 1980 was 93 and 68 cm, respectively. However, only 23 cm fell during the Concord fruit bearing season in 1980, which was the lowest rainfall year on record since 1954.

Fruit, loads used in this study were established by using a 30+10 or 60+10 balanced pruning schedule (30 or 60 fruiting nodes retained for the first 454g (1 lb) of prunings and 10 additional nodes retained for each additional 454g of prunings removed). Six-node canes were retained for fruiting.

For initiation of the study, the previously established irrigation and fruit load plots were subdivided to allow two levels of K fertilization (0 and 450 kg/ha actual K). K was applied as potassium sulfate and banded approximately 1 m either side of the row at the time of budbreak each year. The experimental design was factorial with six replications of four vine plots.

Individual vine yields and pruning weights were recorded each year. Petiole samples for analysis were collected both years at 60 days after bloom from the first leaf distal to the last cluster on fruiting primary shoots that were exposed to the sun. The petioles were separated from the blades, air dried, ground in a micro-Wiley mill to pass through a 40-mesh

screen and stored in tightly capped glass vials. Samples were digested using heat, H₂SO₄, and H₂O₂, cooled to room temperature, filtered, and brought to volume with deionized water. K, Mg and Ca were determined flame photometrically using a Beckman Model DU spectrophotometer.

Fruit was harvested and three representative basal clusters were collected on 6 September 1979 and on 9 September 1980. Samples were immediately frozen for later quality analysis.

For analysis, samples were thawed, and the percentage of green fruit (by number) was determined. The samples were then blended in a laboratory blender for 15 seconds and heated in a water bath at 85°C for 1 hour to extract, color and solublize tartrates. After cooling to 20°C, pulp was removed by straining through cheesecloth. Percent soluble solids was determined using a Bausch and Lomb Abbe refractometer. K content of juice was determined flame photometrically using a Beckman Model DU spectrophotometer.

A 2 mL-sample of the juice was diluted to 100 mL with deionized water, acidified to pH 1.5 with HCl and centrifuged for 30 minutes at 4000 rpm. Absorbance was read on the centrifuged samples using a Bausch and Lomb spectrophotometer (Model 340) at 520 nm. A 5 mL sample of juice was diluted to 125 mL with deionized water, pH was determined, and the sample was titrated to pH 8.4 with 0.1 N NaOH to determine acidity.

RESULTS AND DISCUSSION

In this study, the only interactions that were significant were interactions involving treatments x years, and the data are presented as main effects for each year.

Irrigation had little effect on petiole content, except for a slight reduction in petiole Mg in 1979 and a slight increase in Ca in 1980 (Table 1). Pruning severity had no effect on the petiole analysis in either year. Petioles from plots receiving K fertilization tested higher in K and lower in Mg and Ca in both years. These effects of K fertilization on petiolar K and Mg were more pronounced during the 2nd year (1980) of K application. Large K applications have been reported to reduce petiolar Mg to near deficiency levels (17).

Total fruit yield was considerably increased by irrigation each year (Table 2). The less severe pruning (60+10) in 1980 and the application of K both years increased yields. The most productive plots both years were the irrigated,

Table 1. Effects of irrigation, pruning severity and potassium fertilization on petiole analysis of Concord grapes.

Treatment	Petiole Content					
	%K		%Mg		%Ca	
	1979	1980	1979	1980	1979	1980
Irrigation						
Irrigated	2.98a [†]	3.46a	1.30b	0.80a	4.38a	3.56a
Not irrig.	2.70a	3.59a	1.46a	0.76a	4.51a	3.38b
Pruning Severity						
60+10	2.78a	3.43a	1.42a	0.80a	4.38a	3.52a
30+10	2.91a	3.62a	1.33a	0.76a	4.52a	3.42a
K Fertilization [‡]						
+K	4.20a	5.48a	1.20b	0.52b	4.32b	3.43b
-K	1.49b	1.57b	1.55a	1.04a	4.58a	3.51a

[†]K fertilization treatments: +K = 450 kg/ha, -K = 0 kg/ha.

[‡]Mean separation within columns and treatments by Duncan's Multiple Range Test, 5%.

60+10 pruned vines receiving K fertilizer. This treatment increased yields by 131% and 111% in 1979 and 1980 compared to the nonirrigated, 30+10 pruned vines without K (data not shown).

Irrigation, more severe pruning (30+10), and K increased node fruitfulness (g fruit/node) in both years (Table 2). Less severe pruning (60+10) reduced node fruitfulness even though total yields were increased. Vine yields were increased by irrigation not only by improving node fruitfulness, but also by increasing vine size (pruning weights) which allows more fruiting nodes to be retained using a balanced pruning system. Pruning severity had little effect on vine size, but K slightly increased the amount of wood produced per vine in 1979. Reducing moisture stress was the most important factor in both years for maintaining vine size and yields.

Irrigation reduced soluble solids levels in 1979 (Table 3), which is in agreement with previous research regarding the effects of irrigation on delaying, or reducing soluble solids content of Concord (10,21). However, in 1980, a year of severe heat and drought, irrigation resulted in an increase in soluble solids content. This result is probably due to the influence of irrigation on maintaining the functional leaf area of the vines. At veraison in 1980, irrigated vines averaged 927 functional leaves per vine compared to nonirrigated vines which averaged only 383. In 1980, soluble solids were only 14.4% on nonirrigated, lightly pruned (60+10) vines without K. This would not meet minimum standards of 15% set by the unfermented juice industry.

Table 2. Effects of irrigation, pruning severity and potassium fertilization on yield and vine size of Concord grapes.

Treatment	Yield				Pruning Wt.	
	MT/ha		g/node		kg/vine	
	1979	1980	1979	1980	1979	1980
Irrigation						
Irrigated	10.7a ^x	12.8a	158a	195a	0.77a	0.57a
Not irrig.	6.4b	8.9b	119b	176b	0.53b	0.36b
Pruning Severity						
60+10	9.0a	11.5a	112b	150b	0.64a	0.46a
30+10	8.1a	10.1b	165a	221a	0.67a	0.48a
K Fertilization ^z						
+K	9.2a	11.8a	148a	198a	0.71a	0.49a
-K	7.9b	9.9b	129b	173b	0.60b	0.45a

^zK fertilization treatments: +K = 450 kg/ha, -K = 0 kg/ha.

^xMean separation within columns and treatments by Duncan's Multiple Range Test, 5%.

Table 3. Effects of irrigation, pruning severity and potassium fertilization on quality and uneven ripening of Concord grapes at harvest.

Treatment	Soluble Solids		Color		Green Fruit			
	% in juice		Abs. @ 520 nm		% by count			
	1979	1980	1979	1980	1979	1980		
Irrigation								
Irrigated	17.3b ^y	16.5a	1.96a	2.19a	.434a	.227a	1.9a	9.1b
Not irrig.	18.1a	15.7b	1.24b	1.42b	.447a	.235a	1.5a	7.1a
Pruning Severity								
60+10	17.4b	15.4b	1.65a	1.86a	.421b	.185b	1.8a	9.3b
30+10	18.0a	16.8a	1.55a	1.76a	.461a	.277a	1.5a	6.9a
K Fertilization ^z								
+K	17.7a	16.3a	1.73a	1.98a	.442a	.250a	1.8a	7.0a
-K	17.8a	15.9a	1.47b	1.64b	.439a	.212b	1.6a	9.2b

^zFertilization treatments: +K = 450 kg/ha, -K = 0 kg/ha.

^yMean separation within columns and treatments by Duncan's Multiple Range Test, 5%.

Table 4. Effects of irrigation, pruning severity and potassium fertilization on acidity and juice potassium content of Concord grapes at harvest.

Treatment	Acidity				K	
	pH		% as tartaric		ppm in juice	
	1979	1980	1979	1980	1979	1980
Irrigation						
Irrigated	3.45a ^y	3.62a	0.75a	0.53a	2088a	2487a
Not irrig.	3.45a	3.60a	0.74a	0.56a	1891b	2288b
Pruning Severity						
60+10	3.45a	3.60a	0.74a	0.56a	1881b	2304a
30+10	3.45a	3.63a	0.75a	0.53a	2096a	2470a
K Fertilization ^z						
+K	3.51b	3.70b	0.74a	0.53a	2152a	2812a
-K	3.39a	3.52a	0.76a	0.56a	1827b	1962b

^zFertilization treatments: +K = 450 kg/ha, -K = 0 kg/ha.

^yMean separation within columns and treatments by Duncan's Multiple Range Test, 5%.

Yield of soluble solids per hectare increased with fruit yield in plots receiving irrigation and K fertilization (Table 3). Even with higher yields of lightly pruned vines (60+10) in 1980 the lower percent soluble solids in the juice prevented a significant increase in soluble solids per hectare.

Juice color was not affected by irrigation, but lighter pruning (60+10) resulted in poorer color (Table 3). K fertilization improved color in 1980. In 1980, the color responded similarly to soluble solids with the nonirrigated, lightly pruned vines without K producing poor color (only .134 absorbency at 520 nm).

Uneven ripening (C green fruit) was not affected by any treatment in 1979 (Table 3). In 1980, irrigation and lighter pruning (60+10) increased the o green fruit at harvest, and K fertilization reduced the extent of uneven ripening.

Juice pH was affected only by K fertilization (Table 4). These effects of K on increasing pH would be even greater if the samples had been placed in cold storage for argol precipitation (17), which is standard procedure for commercial juice production. In general, the extreme heat, of the 1980 season resulted in higher pH and lower acidity in all treatments.

Juice K content was increased by irrigation and K fertilization in both years and by a lighter fruit load in 1979.

CONCLUSIONS

The grapevines used in this study showed an immediate response to K fertilization through increased petiolar K, yields, and vine size. Juice pH was increased by K fertilization with an accompanying increase in juice K content. However, K fertilization had no effect on percent soluble solids content. Irrigation and lighter pruning (60+10) resulted in the expected yield increase. Light pruning reduced juice quality. In the year with normal rainfall (1979), irrigation also reduced quality; however, under severe water stress conditions (1980), supplemental irrigation improved juice quality by preventing loss of the photosynthetic leaf area of the vines.

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