Response of Grape Cultivars to Nitrogen and Phosphorus

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Abstract

The response of 11 different varieties of grapes treated with different levels of N was studied over a seven-year period. Phosphorus fertilizer was applied midway through the study. Tissue samples were tested for total P and NO_3-N content, and yield determined annually. The results showed a positive interaction in terms of increased yield between N and P when sufficient quantities of both nutrients were provided.

Introduction

Arizona farmers are attempting to increase the production of profitable low-water use crops such as grapes. Although grapes have been grown in Arizona for decades (4), their production is expanding in terms of area and varieties. At some locations, plantings are being made using water harvesting systems (5) in order to supply water from precipitation runoff instead of using ground water for irrigation.

Nitrogen and P are essential for both plant growth and reproduction. Unlike other horticultural crops, the grapevine has a low demand for nutrients and has minor mineral deficiency problems. This is probably due to the ability of the plant to adapt to a wide range of soil fertility conditions and its large capacity to store the nutrients in its trunk, roots, and other parts. Moreover, the grapevine has the ability to redistribute the stored nutrients during periods of supply shortage or high nutrient demand. The deep root system enables the plant to effectively explore the surface soil as well as the subsoil. Thus, it is not surprising that a significant response by vines to fertilizers is limited and mostly confined to N. Phosphorus deficiency in grapes has only recently been reported (2,6,7) due to the fact that the P requirement of vines is low and the supplying power of soils of most grape-producing regions generally exceeds the rate of removal of P.

The objectives of this study were to evaluate NO_3-N and P content of leaf petioles, and to examine the interactive effects of NO_3-N and the petiole-P content of the plants and their role on 11 varieties of yields of wine grapes produced on a Terra Rossa soil.

Materials and Methods

The study was conducted on a mature vineyard at the University of Arizona Oracle Agricultural Center (Page Ranch), located 50 km north of Tucson, Arizona, at an elevation of 1300 m with an average annual precipitation of about 370 mm. The dominant soil of the area is White House sandy loam (fine, mixed, thermic, Ustollic Haplargid). The location is clearly within the Border Wine Belt (3) and wine produced from grapes grown at this location has been of very good to excellent quality.

Research on grapes and other crops produced by water harvesting was initiated at The University of Arizona Oracle Agricultural Center in 1972 (3, 4). The grapes were planted on 1.22 m wide water ways between sodium chloride treated catchments which are part of the water harvesting system (5). The vines were spaced 2.25 m apart in the row and 9.2 m between rows (catchment width). All vines were pruned according to commonly accepted practices for each variety and trained on a 1.75 m double wire overhead trellis system. Excess precipitation from the catchments was collected in a reservoir for supplemental irrigation during dry periods. Supplemental water was provided by a drip irrigation system using water from the reservoir.

Eleven varieties of grapes were planted in 1972 (4). These varieties were as follows:

1)	Barbara (B)	7)	Ruby Cabernet (RC)
2)	Cabernet Sauvignon (CS)	8)	Sauvignon blanc (Sb)
3)	Chardonnay (C)	9)	Sylvaner (S)
4)	Chenin blanc (Cb)	10)	White Riesling (WR)
5)	French Colombard (FC)	11)	Zinfandel (Z)
6)	Gamay (G)		

The fertilizer study began in March 1981 with an annual application of three different rates of nitrogen. Zero, 155, and 310 g N per vine were applied as urea. The vines were tested for both NO_3^- and total-P in petioles. All plots received P fertilizer injected by tractor mounted equipment on 20 March 1985.

Treatments were replicated twice and petioles were sampled four times during each growing season. Samples of leaves and petioles reported in this study were collected on 13 May and 13 June, 1988. The samples were analyzed by standard laboratory procedures. Grapes were harvested annually by hand and weighed when maturity was reached for each variety. The means for the grape yields were calculated on the basis of both year and N treatment.

Results and Discussion

Effect of N Fertilizer on P Content of Grapes: The results of the NO_3-N and total P analysis for the 1988 season are shown in Table 1. There were clear differences in petiole NO_3-N among varieties. Results for both high and medium rates of N fertilizer fell within the adequate to excessive range, while the NO_3-N content of the petioles for the low N treatment was within the deficient to questionable range. The NO_3-N content of petioles varied according to variety of grape (1) and values for the various varieties used in this study were generally consistent season after season (data not shown).

Nitrogen fertilizer maintained a lower but sufficient P content of petioles (Table 1), in contrast to the accumulation of petiole-P when grapes were deficient in N. Lower values of NO_3-N corresponded to the higher total petiole-P values, indicating that under low N conditions, plants tended to accumulate a substantial amount of P in tissues without assimilating it into organic compounds.

Although the N study began in 1981, deficiency symptoms did not appear on the control plots until 1987. Yields were not determined after 1988 due to the deterioration of the reservoirs and low precipitation which resulted in a lack of irrigation water. However, it should be pointed out that the water harvesting system provided adequate irrigation water from precipitation runoff annually from 1971 through 1988.

Examples of low, medium and high yielding plants are shown in Table 2. Barbara is shown as a typical medium producing variety under these conditions. Yields tended to increase after the P application in the spring of 1985. The N-treated plants generally produced more than the controls.

Cabernet Sauvignon is shown as a low producing variety. Trends of response to N and P are the same as for Barbara. Note the overall poor production of vine number 2 with the high N treatment. Sauvignon blanc was a high producing cultivar, but data were incomplete due to missing plants. White Riesling was selected as a high yielding variety. There is a clear response to P with the yield increase in 1985, although, the trend is weak with respect to N.

Yields of the 11 varieties were highly variable ranging from 0.1 to 13.0 kg for individual plants over the 1983 to

1987 period. Initial harvest yields for 1974 ranged from 0.7 to 3.1 kg per plant (3). Mean yields for 1983 through 1987 for N treatments for 8 of the 11 varieties where complete data are available are shown in Table 3. Yields increased with time, particularly after the P application in 1985. The response to N was not so pronounced, probably because one replicate of the high N treatment was on a slightly steeper slope where irrigation and rainfall were not very efficient due to rapid runoff. In addition, yield variation was caused by losses to insects (bees and wasps), birds, and porcupines. Pruning differences from plant to plant and year to year probably affected yields to a small extent. Also, some of the same plants had been infected by cotton root rot (Phymatotrichum omnivorum L.) prior to the time these studies began (3, 6) and may have continued to affect the vigor of individual vines. Most individual plants tended to produce a constant yield with respect to time and P application.

It is interesting to note that other grape plots have survived several years without supplemental water and maintained low to moderate production at this location. For example, nine Cabernet Sauvignon vines which were not irrigated during the 1987 season produced an average of 2.4 kg fruit per plant. Eight Sauvignon blanc plants produced an average of 3.6 kg per plant. Yield potential of grapes is strongly influenced by treatment and environmental conditions for the previous growing season.

Summary and Conclusions

Response of 11 varieties of grapes to N and P fertilizer were studied. Soil application of N and P increased the total P content of plant tissues and grape yields, indicating a positive interaction (in terms of plant growth and increased yield) between N and P fertilizers. Under N stress, the total P tended to accumulate in leaves and petioles. However, accumulated P was not assimilated and did not affect the yield. Therefore, NO_3-N should be monitored during the growing season and should be associated with analysis of P in plant tissue. Under N stress conditions, growth tends to slow dramatically, thereby, P translocation into the youngest growth is reduced and tends to accumulate in large amounts in the older leaves. Thus, under these conditions, P analysis of grape leaves could be misleading and result in a false indication of the P status of the plant.

References

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Table 1. Influence of nitrogen fertilizer on petiole nitrate and petiole phosphorus for eleven varieties of grapes, University of Arizona Oracle Agricultural Center, 1988.

Variety*	Control (0)			Medium (155)			High (310)		
	13 May		13 June	13 May		13 June	13 May		13 June
	NO_3-N	Total-P	Total-P	NO_3-N	Total-P	Total-P	NO_3-N	Total-P	Total-P
	ppm**								
B	320	4130	4780	1410	2880	1250	1730	2690	2460
Cb	350	6500	6500	2820	3560	1500	2940	4130	3380
Ch	250	5440	5500	670	4880	2970	1280	3750	2630
CS	460	7180	4690	2240	5880	2340	1910	6690	3460
FC	530	6190	5750	1820	3810	1690	2010	6380	3380
G	320	5560	5000	2760	2250	1690	3830	1500	1000
RC	390	5630	4690	1670	3750	1310	3280	3560	1500
S	300	6000	6000	1530	4340	2970	2380	2750	1380
Sb	320	7060	5380	1400	5630	3800	1630	2190	1630
WR	440	6690	5220	1400	4630	3380	1470	5440	3440
Z	410	5560	3690	1800	4750	3380	2560	2750	1130

Nitrogen Treatments, g Per Vine; Sampling Dates.

*See the list in the text for abbreviations of varieties.

**The data presented in this table are the means of two replications of each N treatment.

Table 2. Individual plant yields of three selected varieties of grapes over the 1983 to 1987 nitrogen fertilizer study period, University of Arizona Oracle Agriculture Center.

			Nitrogen Rate (g/plant)			
Variety	Season	Plant	Control (0)	Medium (155)	High (310)	$\bar{X}$*
			Grape Yield --- kg/plant ---			
B	1983	1	1.8	4.7	4.9	3.8
		2	3.4	2.6	2.0	2.7
	1984	1	1.0	11.0	5.6	5.9
		2	5.8	4.8	2.0	4.2
	1985	1	1.8	6.7	5.6	4.7
		2	2.8	6.4	4.0	4.4
	1986	1	3.2	6.2	10.0	6.5
		2	4.1	6.0	4.1	4.7
	1987	1	4.6	8.3	7.9	6.9
		2	6.7	6.8	4.4	6.0
		$\bar{X}$**	3.4	6.4	5.1	
CS	1983	1	1.0	1.2	0.9	1.0
		2	1.0	0.5	0.6	0.7
	1984	1	0.9	3.5	2.6	2.3
		2	1.4	1.2	1.1	1.2
	1985	1	0.8	4.9	2.5	2.7
		2	2.0	2.0	1.3	1.8
	1986	1	4.3	5.8	5.3	5.1
		2	4.8	3.3	1.6	3.2
	1987	1	4.4	6.4	5.4	5.4
		2	4.4	4.9	1.1	3.4
		$\bar{X}$**	2.5	3.4	2.2	
WR	1983	1	1.9	4.0	3.9	3.3
		2	4.2	4.6	4.8	4.5
	1984	1	3.0	3.3	3.8	3.4
		2	2.4	3.1	2.8	2.8
	1985	1	3.4	3.3	5.6	4.1
		2	1.6	5.8	4.0	3.8
	1986	1	4.6	4.0	6.1	4.9
		2	8.1	6.4	4.1	6.2
	1987	1	6.7	2.6	3.8	4.4
		2	7.1	5.3	5.7	6.0
		$\bar{X}$**	4.3	4.2	4.5	

*Average yield for 3 N treatments (control, medium, and high) for each plant, each year.

**Average yield of each variety for each individual N treatment over 5 years.

Table 3. Mean yields of eight varieties of grapes as affected by N and P fertilizers, University of Arizona Oracle Agricultural Center, 1983 to 1987.

	Nitrogen Treatment (g/plant)			
Season	Control (0)	Medium (155)	High (310)	$\bar{X}^*$
	Grape Yield			
	kg/plant			
1983	3.1	3.1	3.3	3.2
1984	2.8	3.9	3.0	3.2
1985	3.0	3.9	3.3	3.4
1986	4.9	4.6	4.6	4.7
1987	4.8	5.8	4.7	5.1
$\bar{X}^{**}$	3.7	4.3	3.8	

*Average yield for the 3 N treatments (control, medium, and high) for each year.

**Average yield for each individual N treatment over 5 years.