The Effect of Three Rootstock Cultivars, Potassium Soil Applications and Foliar Sprays on Yield and Quality of *Vitis vinifera* L. cv. Ronelle in South Africa

Eunice Avenant[1], J.H. Avenant[2] and R.O. Barnard[3]

1) Elsenburg College of Agriculture, Private Bag X1, 7606 Elsenburg, South Africa

2) ARC-Nietvoorbij Centre for Vine and Wine, Private Bag X5026, 7599 Stellenbosch, South Africa

3) Department of Plant Production and Soil Science, University of Pretoria, 0002 Pretoria, South Africa

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The early black cultivar Ronelle is the major export table grape produced in the northern summer rainfall area of South Arica. In a rootstock trial at Roodeplaat near Pretoria, low yield, poor quality and low export mass as well as typical potassium (K) deficiency symptoms were observed for Ronelle grafted onto 110 Richter, despite K saturation percentages of 6,3% and 6,0% in the topsoil and subsoil respectively. The effect of 500 kg ha^{-1} and 1 000 kg ha^{-1} soil-applied K combined with a 0,02% foliar application of K was investigated for Ronelle grafted onto 110 R (*V. rupestris x V. Berlandieri*), 101-14 Mgt (*V. riparia x V. rupestris*) and 143 B Mgt (*V. riparia x V. vinifera*). The K fertilizer treatments were applied only once, before budbreak. Three foliar sprays were applied annually, at two-week intervals, commencing at 15 cm shoot length. Results after two seasons showed that neither high levels of K fertilizer, nor K foliar sprays improved yield or quality of Ronelle on 110 R. The K content of leaves was not significantly affected by any of the K treatments. Leaf K levels of 110 R were significantly lower compared to those of 143 Mgt, but the leaf K content of all three graft combinations was above the minimum norm. Apparently there is no effective cure for established Ronelle/110 R vineyards with K deficiency problems and it is recommended that the Ronelle/110 R graft combination is not used in future.

The early black cultivar Ronelle is the major export table grape produced in the northern summer rainfall area of South Africa. The major regions for table grape production in this area are Warmbaths/Nylstroom, Potgietersrus/Pietersburg and Brits/-Rustenburg (Avenant, 1994). In 1994 Ronelle comprised 25%[1] of the total area under table grapes in this area and 46% of the total number of cartons exported from these regions. The fact that Ronelle fetched the highest price per carton (R34,92) on the export market in 1992, as well as the highest average price of R25,26 from 1988 to 1992 (Anon., 1994), emphasises the economic importance of this cultivar.

Rootstocks used for Ronelle in the northern summer rainfall area of South Africa are Ramsey (35,4%), Jacquez (23,2%), 99 R (39,2%), 110 R (2,1%) and US 2-1 (0,39%)[1]. In a rootstock trial at Roodeplaat near Pretoria (25°35'S, 28°21'O), low yield, poor quality and low export mass as well as typical potassium (K) deficiency symptoms (marginal chlorosis, marginal burning and upward curling of leaf edges, smaller berries, uneven berry size and lower bunch mass) were observed for Ronelle grafted onto 110 R, in the 1988/89, 1989/90 and 1990/91 seasons (Avenant, 1991). Results of leaf analysis from vines in this trial (Table 1) showed sub-optimal leaf K levels for Ronelle/110 R, intermediate levels for 101-14 Mgt and optimal to high levels for 143 B Mgt, while the K saturation of both the top and the subsoil exceeded 4% of the CEC (6,3% and 6,0% respectively) (Avenant, 1991).

TABLE 1

K content of leaf blades and petioles at berry set for Ronelle on three rootstock cultivars in a rootstock evaluation trial, Roodeplaat (1989/90 season) (Avenant, 1991).

Rootstock	K content (%)	
	Petiole	Leaf blade
110 R	0,71	0,67
101-14 Mgt	0,96	0,79
143 B Mgt	1,60	0,91
K norms at berry set (Conradie, 1986)		
min.	1,00	0,65
max.	2,90	1,30

The rootstock significantly affects the nutritional status of the scion (Cook, 1966; Boulay, 1988; Volpe & Boselli, 1990; Fardossi, Hepp, Mayer & Kalchgruber, 1991) and plays an important role in vine vigour and production (Cook, 1996), grape (Carstens, Burger & Kriel, 1981) and wine quality (Ough, Lider

1) Vine sales by the Northern Transvaal Co-Operative (1978-1983) and the Transvaal Table Grape Producers' Association (1983-1994).

& Cook, 1969). Part of the rootstock effect seems to involve mineral nutrition relationships (Archer, 1981). Delas & Pouget (1988) stated that the nutritional status of the scion is the result of the rootstock's ability to absorb nutrients and the scion's ability to transport and accumulate nutrients. In agreement with this statement, Ruhl, Clingeleffer, Nicholas, Cirami, McCarthy & Whiting (1988), Ruhl (1989b, 1991) and Ruhl, Clingeleffer & Kerridge (1990) found that rootstock genotype affects K accumulation in the scion.

Potassium is an essential monovalent cation for all higher plants (Epstein, 1972). Plants need K for activation of certain enzymes, protein synthesis, photosynthesis, regulating water relationships, cell division as well as the neutralisation of organic acids and maintaining the cation-anion balance (Cook, 1966; Boulay, 1988; Volpe & Boselli, 1990; Fardossi *et al.*, 1991). Several researchers reported the importance of K ions in the acid balance of grape juice, as well as the pH, colour and quality of wine (Dundon, Smart & McCarthy, 1984; Conradie & Saayman, 1989b; Ruhl, 1989a, 1989b, 1991; Ruhl *et al.*, 1990). The important role of K regarding TSS and berry size necessitates proper K nutrition of table grapes (Conradie, 1994).

Volpe & Boselli (1990) evaluated the cultivar Croatina on 10 different rootstock cultivars, including 99 R, 1103 P and 101-14 Mgt. Results over three seasons showed no significant rootstock effect on yield, although the nutrient status of vines was significantly affected: petiole K content of 99 R and 1103 P was lower than that of 101-14 Mgt, while the opposite was observed for Mg, Ca, N and P.

Several other researchers also investigated the effect of rootstock cultivar on K accumulation and K status of the vine and the main results obtained can be summarised as (i) Rootstock cultivar differences exist regarding absorbtion of nutrients such as K (Ough *et al.*, 1969; Hale, 1977; Boselli, Volpe & Fregoni, 1987; Etourneaud & Loue, 1987; Pouget, 1987; Loue & Boulay, 1987; Boulay, 1988; Ruhl *et al.*, 1988; Ruhl, 1989b, 1991), (ii) Regarding chemical composition of petioles and/or berry juice, cultivar differences were observed with a specific scion cultivar on different rootstock cultivars as well as with different scion cultivars on the same rootstock cultivar (Ough *et al.*, 1969; Hale, 1977; Loue & Boulay, 1987; Pouget, 1987; Ruhl *et al.*, 1988; Ruhl, 1989b), (iii) The potassium absorption and accumulation ability of several rootstock cultivars is negatively correlated with Mg absorption ability (Scienza, Casassa, Visai & Conca, 1984; Loue & Boulay, 1987; Pouget, 1987; Boulay, 1988; Ruhl, 1991), (iv) The rootstock cultivar affects juice pH of the scion by affecting its K content (Ough *et al.*, 1969; Hale, 1977; Ruhl *et al.*, 1988; Ruhl, 1989b) and (v) The variation in K accumulation ability of different rootstock cultivars may be ascribed to their genetic origin: *V. champini* rootstocks, which induce a high juice K (Hale, 1977; Ruhl, 1991) as well as a high malate concentration and high pH, impair wine stability (Hale, 1977); and *V. Berlandieri* seems to have a better K absorption and accumulation ability than *V. rupestris* (Boselli *et al.*, 1987; Loue & Boulay, 1987).

The visual symptoms of K deficiency as a common nutrient disorder are often observed in European vineyards, but less frequently in South Africa and California (Saayman, 1981). With K deficiency the K content of blades and petioles at véraison will be below 0,55% and 0,90%, respectively (Conradie, 1986). Potassium deficiency symptoms on vine leaves can be divided into three categories, namely (i) Early in the season, visual symptoms of K deficiency usually appear on leaves in the middle part of the shoot (up to the 10th node) and include upward or downward curling of leaf edges, as well as marginal chlorosis and marginal burning (Cook, 1966; Conradie, 1987), (ii) "Spring fever" or "false potassium deficiency" (FK) symptoms are temporary symptoms similar to those of (i), which develop in springtime during the period before bloom and it is suggested that FK is a nutritional disorder caused by temporarily lower K levels and elevated total N and NH_4-N levels in leaf tissue (Christensen, Boggero & Bianchi, 1990). According to Christensen *et al.* (1990) FK tissue nutrient levels recover to near normal levels by bloom, when FK symptom development has ceased, and (iii) The "black leaf" symptom appears later in the season (from véraison onwards) due to a sudden K deficiency which develops in the leaves, because during ripening, when the K supply from the soil is inadequate to satisfy the peak K demand of the bunches, K migrates from the leaf blades to the bunches (Cook, 1966; Saayman, 1981).

In South Africa a K/CEC ratio of 0,04 is accepted as a general guideline for sufficient K saturation of the soil (Saayman, 1981). Saayman (1981) and Conradie & Saayman (1989a) refer to a minimum norm of 50 mg kg^{-1} K for soil under South African conditions. Potassium fertilization at rates sufficient to prevent the occurrence of deficiency symptoms is required for optimal production, while excessive K applications have little effect (Morris, Cawthorn & Fleming, 1980; Conradie & De Wet, 1985; Conradie & Saayman, 1989a). For corrective fertilization, depending on the severity of the deficiency, rates of 400 - 800 kg K ha^{-1} are recommended in Southern France, while 1 100 (Saayman, 1981) to 2 800 kg K ha^{-1} (Christensen, Peacock & Bianchi, 1991) is applied in California. According to Cook (1966) a minimum rate of 0,6 kg K per vine (K_2SO_4) is required for recovery within one year. A single application of 1 kg K per vine (K_2SO_4) gave a good correction of K deficiency for six to eight years (Christensen, 1975). According to Christensen *et al.* (1991) K fertilization may correct a deficiency condition for 5 to 10 years, depending on the severity of the deficiency as well as the rate of K fertilization. High rates of K fertilization may cause a high total acidity, as well as high juice pH, with adverse effects on juice and wine quality, while table grape quality is not impaired by a high K status (Christensen, Luvisi & Schrader, 1994).

Potassium fertilization of vineyards with an initial sub-optimal soil K content increased yield and shoot mass (Conradie & De Wet, 1985; Conradie & Saayman, 1989a), petiole K content (Christensen, 1985; Morris *et al.*, 1980; Conradie & De Wet, 1985; Conradie & Saayman, 1989b), juice pH and juice K (Morris *et al.*, 1980; Conradie & De Wet, 1985; Conradie & Saayman, 1989b). It should, however, be noted that the results of Valenzuela & Ruiz (1984), Conradie & De Wet (1985) and Conradie & Saayman (1989a) showed that a saturation level is reached, where no significant further increase in yield and shoot mass is obtained with increasing rates of K fertilizer. Research results regarding the effect of K fertilization on vineyards with optimal soil K levels showed that, although exchangeable K in the soil may be significantly increased by K fertilization (Dundon *et al.,* 1984), yield, leaf, must and wine composition do not change significantly (Saayman & Conradie, 1982; Dundon *et al.,* 1984).

For producers who have already planted Ronelle on 110 R, it is important to know whether K deficiency symptoms can be corrected by K fertilization, while for new plantings the effect of the rootstock cultivar on the nutritional status, vigour and production of the scion has to be considered. The purpose of this study was to determine the effect of soil-applied K alone or in combination with K foliar sprays on the performance of Ronelle grafted onto three rootstock cultivars in order to find answers to the following questions:

(1) How does the rootstock cultivar affect yield and quality?

(2) Can yield, export mass, bunch mass and berry mass be improved by K fertilization?

(3) How did the soil K status change after K fertilization and were these changes reflected in the leaf K content?

MATERIALS AND METHODS

The study was conducted at Roodeplaat, near Pretoria, in a seven-year-old randomised block rootstock trial, with seven blocks and 32 scion/rootstock combinations. *Vitis vinifera* cv. Ronelle grafted onto three different rootstocks cultivars, *viz.* 110 R (*V. rupestris x V. Berlandieri*), 101-14 Mgt (*V. riparia x V. rupestris*) and 143 B Mgt *(V. riparia x V. vinifera)* was used in this trial. Table 2 shows the experimental design of the Roodeplaat trial, with rootstock cultivars and K fertilizer treatments evaluated for Ronelle. The vines, planted 3.0 x 2.0 m apart, were double split cordon trained on a Trentina trellis and pruned to 10 and 8 spurs respectively on the upper and lower split cordons.

The vineyard was established on a dark brown sandy clay loam soil classified as a Hutton form (Soil Classification Working Group, 1991), containing 26% and 32% clay in the topsoil (0 - 200 mm) and subsoil (200 - 600 mm) respectively. In 1985, before the establishment of the vineyard, the K saturation of the soil was found to be 4,5% (topsoil) and 3,0% (subsoil). During soil preparation 950 kg KCI (50% K) and 950 kg superphosphate (10,5% P) was band placed at a depth of approximately 45 cm in the subsoil, while superphosphate was broadcast on the topsoil at a rate of 130 kg per hectare. Subsequent to this, no fertilizer was applied until the K fertilizer trial commenced in 1991. In 1991, before commencement of the K fertilizer trial, soil samples were taken in each main plot in each of the seven blocks and the K saturation of the soil was found to be 6,3% (topsoil) and 6,0% (subsoil).

The experimental design was a double split plot with rootstocks as the main plots in a completely randomised block design. Each of the rootstock plots consisted of five vines and was divided into three single-vine split-plots, each separated by a buffer vine. These single-vine split-plots randomly received 0,500 and 1 000 kg K ha^{-1} (0, 0,75 and 1,5 kg K_2SO_4 per vine). The K_2SO_4 dosage for each single-vine split-plot was divided equally between eight 50 cm deep holes, drilled with a soil auger, and evenly spaced around the vine at a distance of 50 cm from the vine. A second split was made on each single-vine split-plot by randomly selecting either the right or left two cordons and applying zero and 0,2% K (KCI) foliar spray treatments three times at two-week intervals, commencing at 15 cm shoot length. The soil application was applied only in 1991, before budbreak, while the foliar spray treatments were applied at the beginning of the 1991 season and repeated during the 1992 season. Normal viticultural practices were applied during the growth season, according to standard Nietvoorbij programmes.

TABLE 2

Experimental design with rootstock cultivars and K fertilizer treatments evaluated for Ronelle.

Experimental design:	Double split-plot in a completely randomised block design		
Main plots:	Rootstocks		
	Rootstock cultivar	*Genetic origin*	
	110 Richter	*V. ruperstris x V.Berlandieri*	
	101-14 Mgt	*V. riparia x V. rupestris*	
	143 B Mgt	*V. riparia x V. vinifera*	
1st split:	*Soil-applied K treatments*	*t* ha^{-1}	*kg* $vine^{-1}$
	K_0	0	0,00
	K_{500}	500	0,75
	K_{1000}	1 000	1,50
2nd split:	*K foliar spray treatments*	*% K*	
	F_0	0,0	
	F_1	0,2	

The following parameters were used for evaluation: yield, shoot mass, total soluble solids (TSS), titratable acid (TA) and pH of berry juice, as well as K content of leaves. Shoot mass was determined during winter pruning. Yield, export, local and culled mass of each data vine were determined on the harvesting dates (15/01/92 and 20/01/93). Average bunch mass was calculated by dividing the yield mass of each data vine by the number of bunches harvested from the vine. A hundred berries were chosen randomly from each data vine to determine berry mass. Thereafter the berries were homogenised in a Waring blender and the homogenate was filtered. The sugar concentration (TSS) was determined with a hand refractometer (Atago dbx 30) and expressed as °Balling (°B). The acid concentration (TA in gl^{-1}) and pH were determined with a Mettler DL21 titrator.

Leaf samples were taken at vḗraison in the 1992/93 season, according to the method of Conradie (1986). The K and N contents of leaves where determined by standard analytical procedures of the Department of Soil Science and Plant Nutrition, University of Pretoria. Soil samples were again taken in 1994 to determine how the K status of the soil was affected by the K soil applications in 1991. Soil samples taken in 1994 were analysed using the standard methods of the Department of Agriculture, Western Cape Province.

Data were analysed with Genstat 5 (1.2) (Genstat 5 Committee, 1987) for normal distribution, whereafter an anlysis of variance was done for each data set. Where statistically significant differences occurred, Tukey's method for pairwise comparisons of means was applied.

RESULTS AND DISCUSSION

Yield and export mass: Results over two seasons (Table 3) showed that the mean yield and export mass of all three graft combinations were not significantly affected by any of the K treatments. These results are in agreement with the findings of Dundon *et al.* (1984) and Ahmedullah, Roberts & Kawakami (1987) that K fertilization of vineyards with optimal soil K levels does not significantly change yield, although petiole K content may be increased. The only significant differences in yield and export mass were between rootstocks, with 110 R inducing the lowest yield, export mass and export percentage, followed by 101-14 Mgt and 143 B Mgt. This supports previous reports of lower yield and export mass for Ronelle and Croatina respectively on 110 R compared to 101-14 Mgt (Avenant, 1991; Volpe & Boselli, 1990), as well as 143 B Mgt (Avenant, 1991).

Bunch and berry mass: Bunch mass and berry mass differed significantly between rootstocks and K foliar spray treatments (Table 3). In agreement with the findings of Avenant (1991), 110 R yielded the lowest bunch mass and 143 B Mgt the highest. Potassium foliar sprays significantly decreased mean bunch mass. This must have been caused by fewer berries per bunch, as they had no significant effect on berry mass. The mean berry mass of Ronelle over all K treatments was in increasing order: 101-14 Mgt (6,03 g), 110 R (6,20 g) and 143 B Mgt (6,91 g). Avenant (1991) also reported a significantly higher berry mass for 143 B Mgt compared to 110 R and 101-14 Mgt, over three consecutive seasons.

Shoot mass and yield:shoot mass ratio: Shoot mass of 110 R was significantly higher compared to that of 101-14 Mgt (Table 3). Yield:shoot mass ratio of Ronelle on 110 R was significantly lower compared to that of 101-14 Mgt and 143 B Mgt. Avenant (1991) reported the same tendency. Shoot mass and yield:shoot mass ratio did not differ significantly between K treatments.

TABLE 3

Effect of rootstock cultivar and K fertilization on mean yield of Ronelle over two seasons (1991/92 and 1992/93).

Parameter	Rootstock cultivar			K soil application ($kg\ ha^{-1}$)			K foliar spray (% K)		Average	CV (%)
	110 R	101-14 Mgt	143 B Mgt	0	500	1 000	0	0,2		
Yield ($kg\ vine^{-1}$)	5,21a	6,03b	6,75b	6,00a	6,15a	5,83a	6,00a	5,98a	5,99	21,9
Export mass ($kg\ vine^{-1}$)	2,11a	3,41b	4,49c	3,31a	3,39a	3,31a	3,39a	3,28a	3,34	35,4
Export (%)	41 a	57 b	67 c	55 a	54 a	57 a	55 a	55 a	56	35,4
Bunch mass (g)	524 a	656 b	705 b	624 a	636 a	625 a	638 a	619 b	628	11,7
Berry mass (g)	6,20a	6,03a	6,91b	6,40a	6,30a	6,44a	6,39a	6,37a	6,38	4,8
Shoot mass (kg)	0,85a	0,66b	0,79a	0,78a	0,74a	0,78a	0,75a	0,78a	0,77	27,7
Yield: Shoot mass ratio	6,50a	9,54b	8,93b	7,96a	8,70a	8,30a	8,59a	8,05a	8,32	29,7

CV = coefficient of variation.

Values in rows within main columns designated by different letters differ significantly at $p \leq 0,05$ (Tukey's test for pairwise comparisons of means).

TSS, TA and pH of berry juice: Regarding the effect of rootstock cultivar on the mean TSS, TA and pH of berry juice, similar trends to those reported by Avenant (1991) were observed. The TSS of juice from 143 B Mgt grafted vines was significantly lower and the total TA significantly higher compared to that of Ronelle on 110 R and 101-14 Mgt (Table 4). This can be ascribed to the fact that yield and bunch mass of Ronelle/143 B Mgt vines were higher than those of 110 R (significantly) and 101-14 Mgt (not significantly). Berry juice pH did not differ significantly between rootstocks.

The mean TSS, TA and pH of berry juice were not significantly changed by any of the K treatments (Table 4), which agrees with the results of Saayman & Conradie (1982) and Dundon *et al.* (1984) regarding K fertilization of vineyards with an initial optimal soil K content.

Soil K content: In 1994 the K saturation (%) of all three soil treatments was above the minimum norm of 4%, as proposed by Saayman (1981). The soil sample data showed the expected pattern of an increase in ammonium acetate extractable K with increasing rates of K fertilizer (Table 5).

TABLE 4

Effect of rootstock cultivar and K fertilization on average TSS, TA and pH of Ronelle berry juice over two seasons (1991/92 and 1992/93).

Parameter	Rootstock cultivar			K soil application (kg ha^{-1})			K foliar spray (%K)		Average	CV (%)
	110 R	101-14 Mgt	143 B Mgt	0	500	1 000	0	0,2		
TSS (°B)	19,00b	18,72b	18,29a	18,71a	18,66a	18,64a	18,69a	18,65a	18,67	2,4
TA (g l^{-1})	3,72a	3,68a	3,85b	3,76a	3,74a	3,75a	3,75a	3,75a	3,75	4,0
pH	3,92a	3,89a	3,90a	3,91a	3,90a	3,90a	3,90a	3,90a	3,90	1,0

CV = coefficient of variation.

Values in rows within main columns designated by different letters differ significantly at $p \leq 0,05$ (Tukey's test for pairwise comparisons of means).

TABLE 5

Soil chemical analysis of the experimental vineyard at Roodeplaat in 1994, 3 years after treatment (average clay content of soil: 26% in the topsoil; 32% in the subsoil).

Treatment	pH (H_2O)		R (ohm)		P (Bray II (mg kg^{-1})		Ammonium acetate extractable cations (cmol$_c$kg^{-1})								S-value		K saturation (%)	
							K		Ca		Mg		Na					
	soil depth (mm)		soil depth (mm)		soil depth (mm)		soil depth (mm)		soil depth (mm)		soil depth (mm)		soil depth (mm)		soil depth (mm)		soil depth (mm)	
	0-200	200-600	0-200	200-600	0-200	200-600	0-200	200-600	0-200	200-600	0-200	200-600	0-200	200-600	0-200	200-600	0-200	200-600
0 kg K ha^{-1} (K_0)	7,0	6,9	900	813	13	19	0,38	0,38	3,39	3,52	1,57	1,58	0,43	0,44	5,77	5,92	6,6	6,4
500 kg K ha^{-1} (K_{500})	6,9	7,0	643	817	10	10	0,86	0,35	3,29	3,34	1,44	1,61	0,44	0,42	6,03	5,72	14,3	6,1
1 000 kg K ha^{-1} (K_{1000})	6,8	6,9	520	850	11	10	1,08	0,32	3,23	3,34	1,32	1,63	0,43	0,43	6,06	5,72	17,9	5,7

Leaf K content: In the case of 110 R, both the leaf blade and petiode K content were significantly lower compared to 143 B Mgt, but did not differ significantly from 101-14 Mgt (Table 6). Although K soil applications increased the ammonium acetate extractable K of K_{500} and K_{1000} plots, K content of leaf blades and petioles did not reflect these differences and was not significantly affected by any of the K treatments. The mean leaf K content of all three graft combinations was above the minimum norms of 0,55% (blades), and 0,9% (petioles) as proposed by Conradie (1986) (Table 6).

Visual K deficiency symptoms on leaves were not observed in the 1992/93 season. This could be ascribed to the fact that the leaf K content of Ronelle/110 R was now within the optimum range. However, problems with small and uneven berry size, low bunch quality and low bunch mass still occurred.

Results after two seasons showed that neither high levels of K fertilizer, nor foliar applications of K, could improve yield or quality of Ronelle grafted on R110. Although K fertilization increased the ammonium acetate extractable K in the topsoil of K_{500} and K_{1000} plots, no significant reaction was observed regarding yield and export mass, yield:shoot mass ratio, berry mass, TSS, TA, pH and leaf K content. This can be ascribed to the fact that the initial K saturation of the soil exceeded the minimum norm of 4%, which agrees with previous findings regarding K fertilization of vineyards with optimal soil K levels (Saayman & Conradie, 1982; Dundon *et al.,* 1984). The results of this study showed that rootstock cultivar, rather than K fertilizer, affects leaf K content of Ronelle. The rootstock cultivar 110 R, which performed worst regarding yield, export percentage and bunch mass, also had the lowest leaf blade and petiole K content at véraison.

The question arises whether a genetically controlled N-K antagonism could be the cause of the observed potassium deficiency problems of the Ronelle/110 R graft combination. The fact that the N content of leaf blades and petioles was not significantly affected by rootstock cultivar rules out this possibility (Table 6). The K deficiency symptoms observed with Ronelle/110 R are believed to be due to a potassium deficiency caused by either a problem with the K absorbtion mechanism of the rootstock and/or the K transport mechanism of the graft combination. Although the leaf symptoms occurred seasonally, this graft combination had problems with smaller berries, uneven berry size, poor bunch quality and lower bunch mass throughout the duration of the trial, which indicate that somehow the development of flower bunches, berry set as well as berry development are adversely affected.

Based on the findings that Ronelle on 110 R showed K deficiency symptoms, low yield, poor bunch quality despite optimal soil K levels, while these problems did not occur with 101-14 Mgt and 143 B Mgt, 110 R seems to be a less efficient K utiliser than the latter. Although several researchers reported cultivar differences regarding K absorption and accumulation by the grapevine (Ough *et al.,* 1969; Hale, 1977; Maggioni & Varanini, 1983; Scienza *et al.,* 1984; Erdei, Miklos & Eifert, 1985; Boulay, 1988; Ruhl, 1989a, 1989b, 1991; Simac, Skaric & Perica, 1990; Volpe & Boselli, 1990; Christensen *et al.,* 1994), the specific mechanism responsible for effective utilisation of specific nutrients is not known.

Each step of K uptake is dependent of the genetic characteristics for metabolic structures (binding sites, carriers, enzymes) which enable ion movement from the outside to the inside of the vine (Maggioni & Varanini, 1983). Cultivar and species differences in K uptake may be explained by differences in K requirements, root morphology (Barber, 1985), root distribution patterns (Williams & Smith, 1991) as well as K absorption and translocation mechanisms in the plant (Maggioni & Varanini, 1983; Scienza *et al.,* 1984; Erdei *et al.,* 1985; Pinton, Veranini & Maggioni, 1990), including ATPase activity, selectivity and concentration in roots, leaves and berries (Boulton, 1980). Erdei *et*

TABLE 6

Effect of rootstock cultivar and K fertilization on mean leaf K and N content of Ronelle at véraison (1992/93).

Leaf blade and petiole nutrient levels		Rootstock cultivar			K soil application (kg ha^{-1})			K foliar spray (% K)		Average	CV (%)
(%)	Min-max (Conradie, 1986)	110R	101-14 Mgt	143 B Mgt	0	500	1 000	0	0,2		
blade K (%)	0,55 - 1,05	0,68a	0,71ab	0,84bc	0,73a	0,74a	0,76a	0,76a	0,73a	0,74	7,4
petiole K (%)	0,90 - 1,80	1,52a	1,95a	2,72b	2,13a	1,95a	2,11a	2,07a	2,05a	2,06	13,5
blade N (%)	1,60 - 2,40	2,72a	2,85a	2,70a	2,74a	2,76a	2,77a	2,77a	2,75a	2,78	4,1
petiole N (%)	0,50 - 0,95	0,57a	0,55a	0,48a	0,53a	0,53a	0,53a	0,53a	0,53a	0,53	9,3

CV = coefficient of variation.

Values in rows within main columns designated by different letters differ significantly at $p \leq 0,05$ (Tukey's test for pairwise comparisons of means).

al. (1985) suggested that differences in K uptake by an effective and ineffective K-utilising cultivar can be attributed to differences both in the rate of uptake and efficiency of translocation to the shoot: with the effective K utiliser, the active mechanism was clearly evident, while active transport of the inefficient K utiliser was negligible - only passive transport was observed at high concentrations and K translocation was also extremely poor. It is possible that 110 R may have a less efficient K uptake and/or translocation system than 101-14 Mgt and 143 B Mgt. Boselli *et al.* (1987) found that *V. Berlandieri* rootstocks have a good to intermediate K uptake ability, even at low concentrations, due to an effective active transport system. In contrast, *V. rupestris* rootstocks have a poor K uptake ability, which is genetically determined. The rootstock 110 R is a *V. Berlandieri x V. rupestris* cross and the poor performance and K uptake of Ronelle/110 R may probably be ascribed to the poor K uptake ability of the *V. rupestris* parent of 110 R.

Establishment cost of table grapes amounts to R38 696 ha^{-1} (without hail netting) (Anon., 1994). Establishment of table grapes under hail netting, as is generally being done in the northern summer rainfall region, already exceeded this amount by 180% in 1988 (Avenant, 1994), while the nett income from table grapes varies between R16 680 ha^{-1} (average for the industry) and R26 139 ha^{-1} (at target production) (Anon., 1994). Table grape production is a capital intensive, but also high-income potential industry. With these facts in mind, as well as increasing input costs relative to prices realised for the product, it is clear that cost effective production practices are of cardinal importance.

Based on a total production of 94 000 t export table grapes (Anon., 1995), with maintenance fertilizer of 3 kg K per ton production (Saayman, 1981), between R620 400 and R1,2 million was spent on K fertilization of table grape vineyards in South Africa during the 1993/94 season. The question arises: in which situations does K fertilization become uneconomic? Saayman (1981) only recommends maintenance K fertilization for vineyards with a K saturation of less than 4% of the CEC. Valenzuela & Ruiz (1984), Conradie & De Wet (1985) and Conradie & Saayman (1989a) reported that a saturation level of soil K is reached when no further increase in yield and shoot mass is obtained with increasing levels of K fertilizer. Therefore, K fertilization at rates exceeding this level, for the purpose of improving growth and yield, is not economically justified.

CONCLUSIONS

The results of this study indicate that K soil applications and foliar sprays for the purpose of improving yield and quality of Ronelle/110 R cannot be recommended for vineyards with a soil K saturation exceeding 4%. The high establishment cost of table grapes, as well as the long lifespan of a vineyard, emphasises the importance of correct decisions regarding scion and rootstock cultivars. Choosing the wrong rootstock cultivar can cause severe losses in production and income during the lifespan of the vineyard. The results of this study emphasise that rootstock cultivars which are recommended for Ronelle should be reconsidered, and that 110 R should be substituted with a better alternative, such as 143 B Mgt.

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