Effect of Three Rootstocks on Grapevine *(Vitis vinifera* L.) cv. Négrette, Grown Hydroponically. I. Potassium, Calcium and Magnesium Nutrition

M. Garcia, P. Gallego, C. Daverède and H. Ibrahim

Ecole Nationale Supérieure Agronomique de Toulouse, Centre de Viticulture et d'Oenologie de Midi Pyrénées, Avenue de l'Agrobiopole-Auzeville – Tolosane. B.P.107 F-31326 Castanet-Tolosan Cedex – France

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In order to study the lack of acidity in wines made out of cv. Négrette, a problem partially due to a high potassium content, this cultivar was grafted onto three different rootstocks, which were then grown in a nutrient solution. Although cation nutrition varied as a function of the rootstock, the potassium level was high in leaves of all three rootstocks. Rootstock 3309 C induced the lowest potassium level. Furthermore, in combination with Négrette, SO 4 absorbed potassium more readily than 101-14 Mgt, contrary to the literature concerning other cultivars. To decrease the absorption of this element by Négrette, 3309 C appears to be the most appropriate rootstock.

A lack of acidity in wines is often observed in some vineyards throughout the world. That is also the case in the Côtes du Frontonnais, south-western France, where Négrette is the principal cultivar, producing wines which are not very acidic and mature quickly.

It is well known that acidity is one of the essential factors determining wine quality, allowing good microbiological stability and consequently better keeping quality (Ribéreau-Gayon *et al.*, 1982; Fleet, 1994; Kandl & Kupina, 1999; Daverède & Carcia, 2000). Because oenological solutions to create the desired acidity are not always satisfactory from a quality point of view, the present trend is to look for solutions at vineyard level. Soyer & Molot (1993) underlined the correlation existing between potassium nutrition of the vine and the lack of acidity in musts and wines.

With the aim of improving the wines of Négrette, in particular their acidity, Daverède (1996) conducted an experiment on the physiology of this cultivar, grafted onto 101-14 Mgt, using a hydroponic culture to avoid the constraints of soil and climate. He varied the K/Ca balances of the nutrient solution in order to exploit the antagonism between potassium (K) and calcium (Ca), keeping the sum of cations constant. This experiment showed that Négrette is able to accumulate large quantities of K in its leaves and berries. Potassium was also found in high quantities in the musts and wines, which were consequently not very high in acidity. A positive correlation between the potassium contents of the leaves and musts (r = 0.95) was also observed.

The effect of the rootstock on the nutrition of the scion and the cation content of leaves is well known (Loué *et al.*, 1984). Delas & Pouget (1979) showed that, on the one hand, the rootstock modifies the mineral nutrition of the vine, its sensitivity to deficiencies and response to fertilisers. On the other hand, the composition of the leaves depends at the same time on the scion and rootstock. Boulay (1988) also demonstrated the importance of these two parameters on potassium nutrition and the acidity of wines.

These results prompted us to test other rootstocks, *viz.* the frequently used 3309 C and SO 4 in this region, in comparison to 101-14 Mgt, and to study their effect on the cation, in particular potassium, nutrition of Négrette.

MATERIALS AND METHODS

The investigation was carried out with (*Vitis vinifera* L.) Négrette, clone 456, grafted onto three rootstocks: 101-14 Mgt (*Vitis riparia* x *Vitis rupestris*), *3309 C (Riparia tomenteux* x *Rupestris martin*) and SO 4 (*Vitis Berlandieri* x *Vitis riparia*). The experiment was carried out under controlled conditions in a greenhouse, with temperature regulated between 20 – 25°C and relative humidity between 70 - 85%. The vines were grown in 30 L containers, filled with 'pouzzolane' (3-15 mm diameter, inert volcanic rock fragments, 19% water-holding capacity, containing 7.2% iron, 10.3% lime and 9% magnesium). The vines were four years old and were irrigated twice a day, using an automated system, with a nutrient solution adapted to the needs of the vine (Daverède & Garcia, 1997). The composition of the nutrient solution (pH 5.8) was as follows: Macro nutrients (in meq L^{-1}); 8.8 NO_3, 1.0 H_2PO_4, 1.0 NH_4, 2.1 K, 6.7 Ca, 2.0 Mg, and micro elements (in mg L^{-1}); 5.9 Fe, 2.0 Mn, 0.05 Mo, 1.5 B, 0.5 Zn, 0.25 Cu.

For foliar diagnoses, leaves were collected at véraison (colour break), as used by Champagnol (1990). The leaves were divided into two batches, *viz.* young (10 apical leaves) and mature leaves. Only the laminae were analysed. The K, Ca and Mg concentrations were determined by atomic absorption spectrophotometry (Perkin Elmer 280), after the plant material had been dried at 80°C, ground to 200 µm fineness, and dry ashed at 250°C for two hours and then at 550°C for eight hours. To the ash was added 1 cm^3 0.5M HCl, the mixture evaporated to dryness, 1 cm^3 of 0.1M HCl added and finally diluted to 100 cm^3.

The experimental layout was monofactorial, with three graft combination treatments and six single vine repetitions. Data were subjected to analysis of variance, and means for each leaf and rootstock category were compared using the Newman (1939) and Keuls (1952) test at a 5% significance level. The means of K, Ca and Mg contents were used to calculate cation ratios.

RESULTS

Potassium concentration

From Table 1 it is evident that the K concentration in young and mature laminae varied significantly according to rootstock. Négrette grafted onto SO 4 was the combination which had the

TABLE 1

The effect of rootstock and leaf age on the K, Ca and Mg content of Négrette laminae.

	Element (% dm)					
	K		Ca		Mg	
Rootstock	ML	YL	ML	YL	ML	YL
101-14 Mgt	1.67° a	1.75° a	3.03* a	1.28* a	0.23° ab	0.23° ab
3309 C	1.39* b	1.57* b	3.64* b	1.35* a	0.27° b	0.29° b
SO 4	1.71* c	2.23* c	2.88* a	1.15* a	0.19° a	0.21° a

ML: Mature leaves; YL: Young leaves. Values in columns followed by the same letter do not differ significantly at a 5% threshold level. For the same element, significant differences between adult and young laminae are indicated with an * and non-significant differences with °.

highest concentrations of K in young and mature laminae, whereas Négrette grafted onto 3309 C had the lowest K concentration for both leaf categories. In all cases, young laminae had higher concentrations of K than mature laminae, but differences were only significant between SO 4 and 3309 C.

Calcium concentration

The Négrette/SO 4 combination had the lowest Ca concentration in young and mature laminae. The Négrette/3309 C combination laminae had significantly higher Ca concentrations than the other two combinations. Again, 101-14 Mgt induced intermediate levels for this element. The differences between rootstocks were not significant in the case of young laminae. Regardless of rootstock, mature laminae always contained significantly more Ca than young laminae.

Magnesium concentration

As for Ca, Négrette grafted onto SO 4 was the combination which had the lowest concentration of magnesium in both leaf age categories. Grafted onto 3309 C, Négrette had the highest concentration of magnesium. As for K and Ca, 101-14 Mgt again induced intermediate Mg levels. Differences in Mg concentrations were significantly different between 3309 C and SO 4 for young and mature laminae. Contrary to what was found for Ca, there was no significant difference in Mg concentrations between young and mature laminae.

Cation ratios

In accordance with results previously obtained (Daverède & Garcia, 1997), 3309 C induced the lowest cation ratios in both young and mature laminae, followed by 101-14 Mgt and SO 4 (Table 2).

DISCUSSION

This investigation showed that rootstock can affect the nutrition of scion leaves and confirmed previous results obtained by our team with Négrette grafted onto 101-14 Mgt (Daverède & Garcia, 1997). The concentration of K in laminae varied according to the rootstock used. For example, 3309 C induced low, 101-14 Mgt intermediate and SO 4 the highest contents of this element in laminae. However, the latter rootstock does not give the same results when grafted to other cultivars, as Boulay (1988) showed, using several scion cultivars of the Languedoc region (Carignan, Cinsault, Syrah, Aramon and Grenache). The results obtained during this study confirmed the importance of the correct choice of rootstock and its effect on the nutrition of the scion, as was also demonstrated by Pouget & Delas (1982).

Daverède (1996) and Garcia *et al.* (1996) found that, under identical experimental conditions, Négrette, despite its low K requirements, has a large assimilation capacity for this element in laminae. The higher the K content of the nutrient solution, the higher was the absorption by Négrette grafted onto 101-14 Mgt, the K content in the plant thus being related to that of the medium in which it was cultivated. Regardless of rootstock, K contents in laminae were high when compared with values usually reported in literature for other cultivars. In our study they were between 1.39 - 1.71% in mature laminae, whereas work by Fregoni (1985), Loué & Boulay (1986), Champagnol (1990) and Garcia & Charbaji (1993) indicated that optimum levels of K are between 0.7 - 1.4% in laminae.

In agreement with Cordeau (1993), we observed that 3309 C induced less K in laminae than the two other rootstocks. On the other hand, contrary to the results obtained by the same author, SO 4 induced higher concentrations of K than 101-14 Mgt.

Regardless of rootstock used in this study, Négrette had a large capacity to accumulate Ca in its laminae. In comparison to the standards established by Fregoni (1985), the Ca levels were optimal or slightly excessive in this study. This phenomenon is prob-

TABLE 2

Effect of rootstock and leaf age on cation ratios in Négrette laminae.

	Young Laminae			Mature Laminae		
Rootstock	K/Ca	K/Mg	K/(Ca+Mg)	K/Ca	K/Mg	K/(Ca+Mg)
101-14 Mgt	1.37	7.61	1.16	0.55	7.26	0.51
3309 C	1.16	5.41	0.96	0.38	5.15	0.36
SO 4	1.94	10.62	1.64	0.59	9.00	0.56

ably related to the climatic condition in the greenhouse with its favourable temperature and water supply, increased transpiration of the plants, as well as the unrestricted supply of Ca (Garcia *et al.,* 1984; Rühl, 1992).

In our investigation the Mg contents in the laminae also varied according to the rootstock used. For Négrette the content of this element in laminae seems proportionally related to the absorption of the two other cations, as was also found for other cultivars by Soyer & Molot (1993) and Faraj *et al.* (1997). According to the standards established by Fregoni (1985), we worked with optimal conditions of nutrition for this element.

Studying cation ratios makes it possible to have a more complete perspective of the nutritional state of the plant (Fregoni, 1985). The differences in cation ratios between young and mature laminae, primarily K/Ca and K/(Ca+Mg), were due to the metabolism of the plant, partly related to the accumulation of Ca in mature leaves. Divalent cations accumulate preferentially in mature laminae, while K is mobilised towards the young laminae with their more active metabolism (Martin-Prével *et al.,* 1984). Cation ratios also underline antagonisms that exist between various cations. Our results showed that the K-Ca and K-Mg antagonisms are well expressed in the case of Négrette. The rootstock 3309 C, which assimilated less K, absorbed more Ca and Mg, a trend which was inversed in the case of SO 4. By comparing the results for cation ratios in mature laminae with the standards published by Fregoni (1985), it is obvious that only 3309 C gave optimum relationships between the elements in laminae. For the two other rootstocks the cation ratios were high because they absorbed more potassium. These results also confirmed that the roots of 3309 C had the weakest potassium absorption, as reflected by the K concentration in laminae.

CONCLUSIONS

This experiment showed the importance of studying individual cultivars, in this case Négrette, which is able to assimilate large quantities of K in leaves, regardless of rootstock. On the other hand, the absorption of this element is also related to the rootstock cultivar used. Judging from K concentrations in laminae, Négrette in combination with SO 4 absorbs K more readily than 101-14 Mgt. This is contrary to literature data obtained for other cultivars.

To decrease the absorption of K by Négrette, 3309 C seems to be the best suited rootstock. However, before recommending this combination for Frontonnais vineyards, it is necessary to study the effect of the three rootstocks used in this study on the quality of musts and wines, particularly on acidity.

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