Effect of Three Rootstocks on Grapevine (*Vitis vinifera* L.) cv. Négrette, Grown Hydroponically. II. Acidity of Musts and Wines

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The cultivar was found to have high potassium content in leaves, musts and wines. To study the contribution of rootstock to this problem, Négrette was grafted onto 101-14 Mgt, 3309 C and SO 4 and grown in the same nutrient solution. The Négrette/3309 combination produced wines with the highest total acidity and tartaric acid content. This graft combination seems to be the best suited to increase the acidity of the must and wine of Négrette.

In a preliminary study using hydroponics Daverède (1996) showed that potassium nutrition had an important effect on the acidity of Négrette wines and that musts and wines have lower acid contents when the potassium level is high. A positive correlation was also found between the concentration of potassium (K) in leaves at véraison and that present in musts.

In the first part of our study (Garcia *et al.*, 2001) it was shown that cation nutrition differs according to the rootstock used, and in particular that potassium in the leaves of Négrette grafted on 3309 C is lower than when grafted on 101-14 Mgt or SO 4. Several authors underlined the relationship between potassium nutrition of the vine and the acidity of musts and wines (Mattick *et al.*, 1972; Champagnol, 1986; Soyer & Molot, 1993). In this paper we present the results of our study on the effect of the three main rootstocks used in Frontonnais vineyards (101-14 Mgt, 3309 C and SO 4) on the cation content and acidity of musts and wines of Négrette.

MATERIALS AND METHODS

The plant material used (cv. Négrette, clone 456; rootstocks 101-14 Mgt, 3309 C and SO 4), the nutrient solution, the experimental conditions and statistical analyses were identical to those described in the first part of this study (Garcia *et al.*, 2001). Because of single fermentations, statistical analyses of the composition of wines were not possible.

During the ripening stage, for each rootstock tested, 100 berries were randomly sampled in triplicate from the six vines of each treatment. The samples were processed according to the method developed by Lamadon (1995). On the musts obtained, pH, total acidity, cations (K, Ca, Mg) and organic acids (malic and tartaric acid) were measured. Malic and tartaric acids were determined according to the method of Dedieu *et al.* (1994), using capillary electrophoresis and an ultraviolet detection system. Separation was done on a 44 cm x 75 µm fused silica column. Total acidity (based on H_2SO_4) was determined according to the method of Delanoë *et al.* (1996).

Microvinifications

The grapes were sampled (4-7 clusters per vine) at a potential alcohol degree of 10.5%. They were then washed, pressed and three liters of must introduced into a standard Inceltech LH SGI fermentor. Because of the limited quantity of grapes, only a single fermentation per rootstock treatment was performed. Once sulfited (60 mg L^{-1}), musts were inoculated with 200 mg L^{-1} of *Saccharomyces cervisiae* (commercial name Uvalin D, a yeast strain having no effect on acidity). Alcoholic fermentation proceeded at a constant temperature of 28°C. After racking, the wines were inoculated with 25 mg L^{-1} of *Leuconostoc oenos* to perform malolactic fermentation. The wines were then bottled and stored at a temperature of 4°C. The levels of cations and organic acids, total acidity and pH were measured on the wines, using to the same methods used for musts.

RESULTS

Potassium concentrations

For the three rootstocks used the K contents in musts were significantly different (Table 1). The rootstock SO 4 induced the highest and 3309 C the lowest K concentrations in musts (Table 1) and in wines (Table 2).

TABLE 1
The effect of rootstock on the composition of Négrette musts.

Rootstock	Potassium ($g\ L^{-1}$)	Calcium ($mg\ L^{-1}$)	Magnesium ($mg\ L^{-1}$)	pH	Titratable acidity ($g\ H_2SO_4\ L^{-1}$)	Tartaric acid ($g.L^{-1}$)	Malic acid ($g.L^{-1}$)
101.14 Mgt	2.32 a	48 ab	65 ab	3.61 a	4.86 a	3.47 a	8.02 a
3309 C	1.98 b	53 a	68 a	3.60 a	4.86 a	3.24 a	6.27 a
SO 4	2.60 c	46 b	62 b	3.72 b	4.89 a	4.85 b	6.54 a

Means within columns followed by the same letter do not differ significantly ($\alpha = 5\%$).

TABLE 2
Effect of rootstock on the composition of Négrette wines.

Rootstock	Potassium ($g\ L^{-1}$)	Calcium ($mg\ L^{-1}$)	Magnesium ($mg\ L^{-1}$)	pH	Titratable acidity ($g\ H_2SO_4\ L^{-1}$)	Tartaric acid ($g.L^{-1}$)	Malic acid ($g.L^{-1}$)
101.14 Mgt	1.56	46	60	4.02	2.38	0.62	0
3309 C	1.40	46	54	3.80	2.91	0.74	0
SO 4	2.04	48	62	4.19	2.47	0.65	0

Calcium and Magnesium concentrations

Négrette grafted onto 3309 C had the highest levels of these two elements in must, followed by 101-14 Mgt and SO 4, differences being significant between 3309 C and SO 4 (Table 1). In the case of wines (Table 2), differences were small between the three rootstocks.

pH and Titratable Acidity

The pH of the must obtained from the Négrette/SO 4 combination was significantly higher than those from the two other rootstocks (Table 1). On the other hand, titratable acidity of musts was not significantly different between the three rootstocks. With 3309 C as rootstock, we obtained the lowest pH in wines and also the highest titratable acidity (Table 2).

Organic acids

The musts obtained with SO 4 as rootstock had significantly higher concentrations of tartaric acid than that obtained with the other two rootstocks (Table 1). In the case of malic acid in musts, there were no significant differences between rootstocks. After malolactic fermentation, concentrations of tartaric acid in wines from SO 4 and 101-14 Mgt were comparable and lower than that of 3309 C (Table 2).

DISCUSSION

These results show that the cation contents and acidity of musts and wines of Négrette vary according to the rootstock used. With 3309 C as rootstock must and wine had the lowest levels of K, whereas SO 4 induced the highest levels of K in musts and wines. Regardless of rootstock, the K content in musts was relatively high, up to 2.60 g L^{-1}, compared to what was found by Ibrahim, *et al.* (2000, 2001) for Cot (Malbec) grafted onto 3309 C, SO 4 and Riparia Gloire de Montpellier. These results confirm the work of Daverède & Garcia (2000), obtained with the same cultivar grafted onto 101-14 Mgt. Here it was shown that Négrette is able to store large quantities of K in its berries, up to 7 g L^{-1}, when this cultivar is cultivated in a K-rich medium. The present investigation also showed that high K concentrations in the musts lead to high K concentration in the wines, resulting in low acidity.

Concerning divalent cation contents, 3309 C induced the highest levels of Ca and Mg in musts, followed by 101-14 Mgt, as was also observed for leaves (Garcia *et al.*, 2001). The Ca and Mg contents found in wines were similar to those obtained by other authors (Rühl *et al.*, 1988; Sentenac, 1992). Whatever the rootstock used, the antagonisms K-Ca and K-Mg, underlined in the first part of our study on the cation ratios in leaves (Garcia *et al.*, 2001), were confirmed here for musts.

From the three rootstocks tested, 3309 C showed the lowest absorption of K, resulting in musts and wines having the lowest pHs. These results confirm the findings of Boselli *et al.* (1986), Ryser *et al.* (1989), Rühl *et al.* (1992) and Ezzahouani & Williams (1995) that there is a close and positive correlation between the pH of musts and wines and potassium nutrition of the vine. Positive correlations between the K content of leaves and musts (r = 0.86), and between the pH of musts and their K content (r = 0.80) were also demonstrated by Daverède (1996).

Moreover, we noted that the differences in pH values between rootstocks were greater for wines than for musts. This amplification of differences confirms the essential role played by K in acidity. Daverède (1996) showed that with wine, rich in this element, potassium bitartrate precipitation will be high and that the pH of the wine will consequently rise.

Although the titratable acidity of musts varied according to the rootstock, we noted on the other hand that this did not conform to the pH of musts. The import of K into the berry causes an increase in pH (Daverède, 1996). Titratable acidity determination is one of the most useful parameters to follow during microvinifications. We observed that 3309 C induced the lowest K content in wines and the highest titratable acidity. This is in agreement with the work of Ryser *et al.* (1989) and Daverède (1996), which showed that titratable acidity was high when K nutrition was low.

With Négrette the rootstock had little effect on the malic acid content of musts, as differences between rootstocks were not significant. Average malic acid contents of musts range between 0.6 - 5.4 g L^{-1} (Champagnol, 1984). In this study we observed higher levels of malic acid in musts of Négrette, between 6.3 - 8.0 g L^{-1}. These contents are also comparable with those found for this same variety in hydroponic culture with 101-14 Mgt as rootstock (Daveréde & Garcia, 2000) or in the vineyard when grafted onto 3309 C (Gallego, 1999).

Differences in tartaric acid concentrations in musts caused by different rootstocks are in agreement with those observed by other authors (Boselli *et al.*,1986; Rühl *et al.*,1988). In our experiment we observed the highest tartaric acid contents with SO 4, the lowest contents with 3309 C and intermediate contents with 101-14 Mgt as rootstocks. These results confirm the work by Daverède (1996) performed with the same cultivar, and show that high K contents in musts are correlated with high acid contents. We observed a positive linear correlation between tartaric acid and K contents in musts (r = 0.85). The levels of tartaric acid found in musts (3.2 - 4.8 g L^{-1}) are comparable with those generally found in musts of mature grapes, 3 - 7g L^{-1} (Champagnol, 1984). However, these concentrations are markedly lower than those found by Garcia *et al.* (1996) in musts for this cultivar in vineyards, grafted onto 3309 C (4.5 - 6.0 g L^{-1}).

With 3309 C the finished wines had the highest concentrations of tartaric acid. The reduction of this acid in finished wines is thus closely related to the level of K contained in must before alcoholic fermentation. High concentrations of K in must cause increased potassium bitartrate precipitation, which then decreases the acidity of the final wine (Daveréde, 1996). However, Gallego (1999) found that tartaric acid concentrations are low in Négrette wines (0.62 - 0.74 gL^{-1}) whatever the rootstock used, which is less than the concentrations of 1.5 to 2.0 g L^{-1} for wines mentioned by Champagnol (1984).

CONCLUSIONS

This study showed the effect of rootstock on the composition of Négrette musts and wines. Wines with the lowest pH, highest titratable acidity and tartaric acid contents are obtained with 3309 C as rootstock. This is related to the fact that this rootstock absorbs less potassium than 101-14 Mgt and SO 4. Therefore, Négrette grafted onto 3309 seems to be the best suited combination to solve the problem of low acidity in Frontonnais wines, and not Négrette grafted onto 101-14 Mgt as recommended up until now.

This study forms part of a more extended research programme aimed at increasing the acidity of certain wines, in particular those of Frontonnais, by means of rational fertilisation. By exploiting the K/Ca antagonism, it is deemed possible to reduce the potassium content in musts, thus obtaining wines with a higher acidity.

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