PETIOLE PHOSPHORUS CONCENTRATION IS CONTROLLED BY THE ROOTSTOCK GENETIC BACKGROUND IN GRAPEVINE: IS THIS A KEY FOR UNDERSTANDING ROOTSTOCK CONFERRED VIGOUR?

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Abstract:

Context and purpose of the study - Grapevine, *Vitis vinifera*, requires grafting on Phylloxera tolerant rootstocks of American origin in most viticultural areas of the world. The most commonly used species in rootstock creation are *V. berlandieri*, *V. riparia* and *V. rupestris*. Rootstocks not only provide tolerance to Phylloxera but assure the supply of water and mineral nutrients to the scion. The objective of this work was to determine to what extent rootstocks of different parentages alter the mineral composition of petioles of grapevine.

Material and methods - *Vitis vinifera* cv. Cabernet Sauvignon clone 169 was grafted onto 13 rootstock genotypes and planted in 2015 in an experimental plot named GreffAdapt. The rootstocks were: Riparia Gloire de Montpellier, 101-14MGt, 3309C, 420A, SO4, 44-53M, Gravesac, Freedom, Dog Ridge, 41B, Rupestris du Lot, 1103P et 110R. The concentration of the following 13 mineral elements was determined in the petioles at veraison (berry softening, 14/08/2017): Nitrogen, Phosphorus, Potassium, Sulphur, Magnesium, Calcium, Sodium, Bore, Zinc, Manganese, Iron, Cupper and Aluminium. Four petioles were harvested from near the clusters from 2 plants for each block (n = 4 per rootstock genotype) and were dried (in an oven at 60°C until they reached a constant mass). Nitrogen content was determined using a Leco FP-528 instrument (LECO, St. Joseph, MI, USA). Other element contents were determined by digesting the plant sample with nitric acid and hydrochloric acid in a CEM Mars5 microwave digester (CEM, Matthews, NC, USA), elemental concentration was determined by reading the solutions on an ICP-OES MS 730-ES (Varian, Palo Alto, CA, USA). Cane pruning weight was also measured for each vine.

Results – The parentage of rootstocks has a significant effect on petiole mineral composition. Rootstocks with at least one *V. riparia* parent reduced the concentration of P and increased the concentration of Mg and S in the petiole of Cabernet Sauvignon.

Conclusions - Rootstocks with a *V. riparia* parent generally confer low scion vigour and we have shown that they also confer low petiole P concentration; this could suggest that P uptake and use is related to rootstock conferred vigour in grapevine. These results will be discussed in the context of previous work we have undertaken to understand the genetic architecture of root growth traits in grapevine. This is the first study to demonstrate a significant link between the genetic origin of a rootstock genotype and its ability to regulation scion P content.

Keywords: Rootstocks, mineral element, phosphorus, grapevine, *Vitis spp.*

1. Introduction.

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INTRODUCTION AND OBJECTIVES

Grapevine, *Vitis vinifera*, requires grafting on Phylloxera tolerant rootstocks of American origin in most viticultural areas of the world. The most commonly used species in rootstock creation are *V. berlandieri*, *V. riparia* and *V. rupestris* coming from different geographical area (Figure 1). Rootstocks not only provide tolerance to Phylloxera but assure the supply of water and mineral nutrients to the scion. The objective of this work was to determine to what extent rootstocks of different parentages (Table 1) alter the mineral composition of petioles of grapevine.

Table 1: The rootstocks used in this study. The full name, abbreviation, genetic background (Galet, 1988) and vigour conferred to scion (Bettiga 2003; Cordeau 1998) for each rootstock are provided.

Rootstock	Abbreviation	Genetic background	Genetic background colour code	Vigour conferred
Riparia Gloire de Montpellier	RGM	*V. riparia*	Riparia	Weak
3309 Couderc	3309C	*V. riparia* tomentosa × *V. rupestris* Martin	Riparia - Rupestris	Weak - medium
101-14 Millardet et de Grasset	101-14MGt	*V. riparia* × *V. rupestris*	Riparia - Rupestris	Medium
420 A	420A	*V. berlandieri* × *V. riparia*	Riparia - Berlandieri	Weak - medium
Teleki n°4 -SO4-	SO4	*V. berlandieri* × *V. riparia*	Riparia - Berlandieri	Weak - medium
44-53 Malègue	44-53M	*V. riparia* cv. Grand glabre × 144 Malègue (*V. cordifolia* × *V. rupestris*)	Riparia - Other	Medium
Gravesac	Gravesac	161-49 Couderc (*V. riparia* × *V. berlandieri* × 3309 Couderc	Riparia - Other	Medium - Vigorous
Freedom	Freedom	1 613 Couderc (*V. longii* × Othello) × Dog Ridge	Other	Vigorous
Dog ridge	Dog ridge	*V. rupestris* Scheele × *V. candicans* Engelmann	Rup - Other	Higly vigorous
Rupestris du Lot	Rupestris	*V. rupestris*	Rupestris	Vigorous
1 103 Paulsen	1103P	*V. berlandieri* Resseguier n°2 × *V. rupestris* du Lot	Berlandieri - Rupestris	Higly vigorous
110 Richter	110R	*V. berlandieri* Resseguier n°2 × *V. rupestris* Martin	Berlandieri - Rupestris	Vigorous
41 B Millardet et de Grasset	41B	*V. vinifera* Chasselas × *V. berlandieri*	Ber - Other	Medium - Vigorous

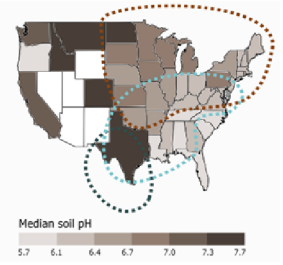

Figure 1: Median soil pH of USA values calculated in 2010 from 4.3 million samples (http://www.cropnutrition.com/efu-soil-ph); and geographic origin of V. riparia (brown), V. rupestris (turquoise), and V. berlandieri (dark blue) (Galet 1988; Galet and Smith 1998)

① Differences in conferred vigour and in petiole mineral element composition are induced by rootstocks

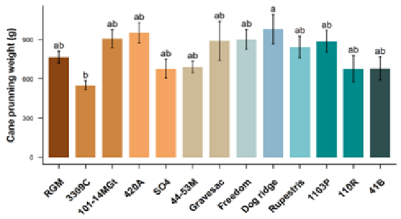

Figure 2: Winter cane pruning weight from 2017 of Vitis vinifera cv. Cabernet Sauvignon grafted onto 13 rootstocks. Means and standard deviations shown (n = 4). Different letters indicate significant differences at P < 0.05, tested using one-way ANOVA with rootstock genotype as factor.

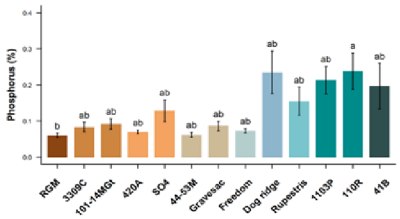

Figure 3: The concentration of phosphorus in the petioles of Vitis vinifera cv. Cabernet Sauvignon grafted onto 13 rootstocks. Means and standard deviations shown (n = 6). Different letters indicate significant differences at P < 0.05, tested using Kruskal Wallis test, with rootstock genotype as factor.

② Rootstock genetic background induces different mineral concentration profiles to the petiole

This is the first time that the genetic background of rootstock has been linked to the mineral profile of the scion, although similar studies have been done for only K content in the petiole (Wolpert et al. 2005), in ungrafted plants for variables associated with drought tolerance (Rossdeutsch et al., 2016) and conferred vigour (Jones et al., 2009).

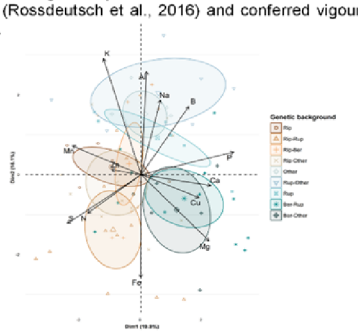

Figure 4: Principal component (PC) analysis of the concentration of minerals in the petiole of Vitis vinifera cv. Cabernet Sauvignon grafted onto 13 rootstocks. The distribution of variables (mineral concentrations given by arrows) and individual observations (symbols) on PC1 and PC2 are given. Ellipses of confidence at the 95 % level are given for each rootstock parentage.

③ Rootstocks with a *V. riparia* genetic background confer low P concentrations to the scion when compared with *V. rupestris* and *V. berlandieri* hybrids

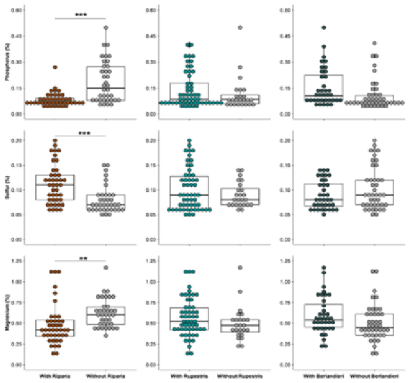

Figure 5: The effect of V. riparia, V. rupestris *and* V. berlandieri *genetic background on petiole phosphorus, sulphur and magnesium concentrations in the scion. Stars indicate significant differences between rootstock genetic background, using a student-test with the Bonferroni correction (*** < 0.001, ** < 0.01, * < 0.5).*

CONCLUSION

Grapevine rootstocks have long been known to modify the mineral profile of the scion, but mechanisms involved are poorly understood. For the first time, the capacity of different rootstocks to alter petiole P concentration was associated with the genetic background of the rootstock genotype. Phosphorus was the major mineral element differentially accumulated in the petiole in response to the rootstock genotype and the concentration of P in the petiole was reduced by rootstocks with a *V. riparia* genetic background. However, rootstocks with a *V. riparia* genetic background also generally confer a lower level of vigour to the scion. This could suggest that P nutrition is related to known rootstock conferred vigour in grapevine. In addition, the poor efficiencies of P uptake from the soil and of P remobilization from perennial woody tissues of *V. riparia* (Gautier et al. 2018) may have indirectly influenced the concentration of other nutrients such S or Mg.

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