The use of rootstock as a lever to face climate change and vineyard dieback

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Abstract

In front of the challenges for viticulture such as climate change or vineyard dieback, the choice of the variety and roostock becomes more and more crucial. To study the rootstock lever in the Bordeaux region, a parcel of Cabernet-Sauvignon (CS), was planted with four rootstocks in 2014. Twenty replicates of each rootstock, 101-14MGt, Nemadex AB, 420A MGt and Gravesac, were set up. Bunch number, yield and pruning weight of vine shoots were measured individually on 240 vines from 2017 to 2021. Since 2020, vine nitrogen status was assessed by yeast assimilable nitrogen measurement on grape juice and water status by $\delta^{13}C$. Grape maturity was measured on 80 samples picked on the 20 repetitions of the four rootstocks. A lower yield was measured for CS grafted onto Nemadex AB due to a lower number of bunches and a lower berry weight. The differences between the three other rootstocks were small but CS grafted onto 420A MGt was the most productive. The CS grafted onto Nemadex AB had the lowest pruning weight while 101-14MGt had the highest. In 2020, $\delta^{13}C$ showed a more moderate water deficit with 101-14MGt and 420A MGt than with Nemadex AB. Surprisingly, the Gravesac was under more stress than the 101-14MGt. The nitrogen status in the berries was higher for Nemadex AB but it is necessary to link this result to the significantly lower berry weight. The rootstock 101-14MGt promoted high sugar accumulation in the berries while 420A MGt allowed to preserve higher acidity. The parcel is still young which may explain some results. All the measurements must therefore be continued over several years to conclude on the effect of these rootstocks on vine development and the quality potential of the production under changing climatic conditions.

Introduction

Terroir parameters such as climate, soil, vegetation material and human practices influence the berry productivity and quality (van Leeuwen et al., 2010). Current climate change influences the phenology of the vine, affects yield and modifies berry composition at maturity (sugars and pH in particular) and therefore the wine. The vineyard dieback, defined as a multi-year decline in yield and/or the gradual or sudden death of vines affects the whole world of viticulture (Riou et al., 2016). In France, the loss of yield is estimated at more than 4.6 hl/ha in 2014. The choice of plant material is a crucial question in order to adapt the vineyard to this context (Renouf et al., 2010, Laveau et al., 2017).
Vinifera grapevines are customarily grafted to prevent injury from biotic problems such as grape phylloxera or nematodes. There is a strong interaction between the rootstock and the scion and the implication of the rootstock type and that of the variety combine (Serra et al., 2014, Ollat et al., 2016, Simonneau et al., 2017). Grafting is currently used in almost all wine-growing countries. Grafting provides not only resistance to soil-borne pests but can also improve adaptability to the various soils and environment, and as such, is also improve yield and fruit quality potential (Jones & Webb, 2009, Stevens et al., 2010, Marguerit et al., 2015, Ollat et al., 2016, Gautier et al., 2019). The two genotypes associated by grafting determine the metabolic functioning and the physiological characteristics of the whole plant and finally the quality potential of grapes produced (Reynolds & Wardle, 2001, Ollat et al., 2016). Varietal responses regarding phenology have been extensively studied and can offer adaptation solutions for generic vineyards (Parker et al., 2020). But this path is not or little possible in

Terroir vineyards, which must maintain the typicity of their production, using the local varieties. In this case, the rootstock becomes the essential element of adaptation to climate change by plant material.

The parcel studied is located in the Medoc region characterized by an oceanic climate, planted in a gravely soil with Cabernet-Sauvignon grape variety, grafted on four rootstocks, 101-14MGt, Gravesac, 420 A MGt, which are frequently used in the Medoc region. The fourth rootstock is the Nemadex Alain Bouquet, selected by INRA (France) in 1987. Nemadex AB delays the contamination by GFLV in infested vineyards because it slows down the multiplication of *Xiphinema index* (Ollat et al., 2011). It is newly planted in France to limit the impact of the fanleaf virus but was not assessed over a long period under production vineyard conditions.

The experimental device aims to evaluate the influence of the rootstock on the quantity and quality potential of the grapes produced. The data presented can provide a short and medium term answer to vinegrowers.

Materials and methods

Study parcel

The study was carried out in Medoc in the Bordeaux region on a parcel of Cabernet-Sauvignon (CS); clone 169, which was planted with four rootstocks in 2014. The parcel was planTwenty repetitions of each four rootstocks, 101-14MGt, Nemadex AB, 420A MGt and Gravesac, were set up. The density of plantation was 9100 vines per hectare and the soil type was a gravel soil. Vines were treated with conventional agronomic practices by the Château, pruned in double Guyot, with an average of three buds per cane. The region's climate was oceanic, with mild winter, wet spring and hot summer.

Vineyard measurements and wine analyses

The measures collected individually on the vines concerned bunches numbers, total yield and pruning weight on 240 vines from 2017 to 2021. Vine nitrogen status was measured on the same vines by spadmeter assessment in 2020 and 2021. Berry samples were carried out annually in 2020 and 2021 just before harvest to quantify the water status by $\delta^{13}C$ assessment. On these same samples, berry maturity was determined by quantifying sugar content (mg/L), total acidity (g/L H_2SO_4) pH and malic acid content (g/L). These measures were realized on 80 samples picked on the 20 repetitions of the four rootstocks.

Statistical analysis

The ranges and quantiles of the data per year and rootstock are represented by boxplots. For each year, a linear regression was established between the parameters and the four rootstock types. Significant differences between rootstocks were determined by post-hoc Tukey tests. Data were analyzed with the statistical software R (http://www.r-project.org}.

Results and discussion

Biomass measurements

During the time of observation (five years), a lower pruning wood weight per vine was measured for CS grafted onto Nemadex AB. The total pruning wood mass was 40 to 45% lower than that of the other 3 rootstocks. Nemadex AB is known as a low vigor confered rootstock (https://plantgrape.plantnet-project.org/fr/). In these production conditions, it appears to be too weak compared to the production objectives. The first 3 years of measurement, there is no significant difference between these 3 other rootstocks. From 2020 on, the rootstock 101-14 MGt had a greater pruning wood weight than 420A and the Gravesac and the difference with the Gravesac is accentuated in 2021 (figure 1A). The 101-14 MGt and 420 A MGt are known as low to medium vigor conferred rootstocks, while Gravesac is referred to as a medium to high vigor conferred rootstock (https://plantgrape.plantnet-project.org/fr/). These results show that the descriptive sheets of the rootstocks do not always correspond to the behaviour measured in specific pedoclimatic situations. It is important to acquire these data in a variety of pedoclimatic conditions and for different grape varieties.

The yield per vine of Nemadex AB is lower than the other rootstocks in a range between 20 to 45%. This is due to a lower bunch number and a lower berry weight. There is no significant difference concerning yield between 101-14MGt, 420A and Gravesac except in 2021 where the CS grafted on 420A was more productive than CS grafted onto 101-14MGt (Figure 1B).

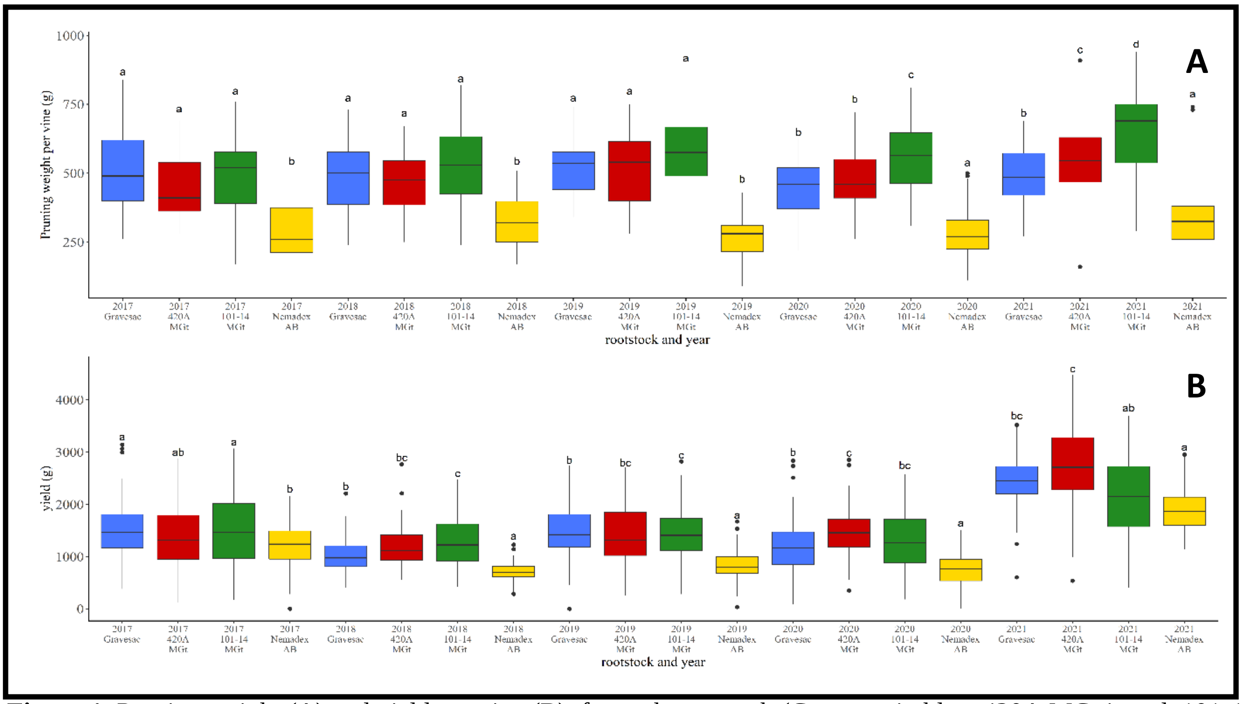

Figure 1. Pruning weight (A) and yield per vine (B), for each rootstock (Gravesac in blue, 420A MGt in red, 101-14MGt in green and Nemadex AB in yellow), from 2017 to 2021. The letters represent significant differences between rootstocks for the same year and were determined by a post-hoc Tukey test with $p < 0.05$.

Nitrogen and water status

No significant difference on spadmeter values was observed with the exception of the CS grafted onto Nemadex AB in 2021, for which combination the values of which were significantly lower. Over the 2 years of measurement, these CS vines grafted onto Nemadex AB showed significantly higher water deficit than those measured on the other rootstocks (Table1). The two years of measurement were not particularly dry. It would be interesting to measure the differences in water and nitrogen behaviour during drier vintages.

Table 1. Nitrogen status measured by spadmeter and hydric status measured by $\delta^{13}C$ assessment for each rootstock, in 2020 and 2021.

Parameter	Spadmeter value				$\delta^{13}C$			
Year	2020		2021		2020		2021	
Gravesac	35.1 +/-2.2	a	39.2 +/-2.4	b	-24.0 +/-0.5	b	-24.8 +/-0.6	a
420A MGt	36.2 +/-2.4	c	39.7 +/-2.8	b	-24.5 +/-0.6	a	-24.9 +/-0.5	a
101-14 MGt	33.8 +/-2.1	bc	39.8 +/-2.4	b	-24.6 +/-0.7	a	-24.9 +/-0.7	a
Nemadex AB	34.8 +/-2.2	ab	37.1 +/-2.7	a	-23.2 +/-0.4	c	-23.6 +/-0.4	b

Berry composition

Regarding technological maturity measured on the same harvesting date, the CS grafted on 101-14 MGt hasd significantly higher sugar levels than the other rootstocks, both in 2020 and in 2021 (Figure 2A). Concerning the total acidity measured in g/L of tartaric acide, the CS grafted on 420A presented the highest acidity, significantly higher than the other rootstocks (Figure 2B). However, this does not translate into significant differences in pH (Figure 2C). By combining these parameters, we obtain a maturity indicator through the Sugar/ Acidity ratio which is higher for the CS grafted onto 101-14 MGt. The lowest ratio is obtained with the rootstock 420 A MGt (Figure 2D). In a context of global warming, these results show that the use of a rootstock such as 420A MGt can preserve the acidity of the berries and limit the accumulation of sugars. The association CS on 101-14MGt is still widely recommended by consultants in this type of pedoclimate. It is time to consider the use of a greater diversity of rootstocks and to favour those which delay technological maturity, preserve acidity and reduce sugar accumulation.

Conclusion

This study shows significant differences in behaviour between the 4 rootstocks set up in this production parcel. The results confirm the low vigor and low production of the Nemadex AB rootstock. They reveal that the 101-14 MGt is the most vigorous of the 4 rootstocks observed under these conditions, while the Gravesac is usually acknowledged to be much more vigorous than the others.
In a context of grapevine decline and global warming, 420 A MGt seems to be a promising rootstock. In our study, it is the most productive and leads to less sugar accumulation while maintaining good acidity. It should be more widely planted in vineyards in such pedoclimatic conditions. This type of study should be duplicated in different pedoclimatic situations in order to improve our unserstanding of the behaviour of the rootstocks combined to different varieties.

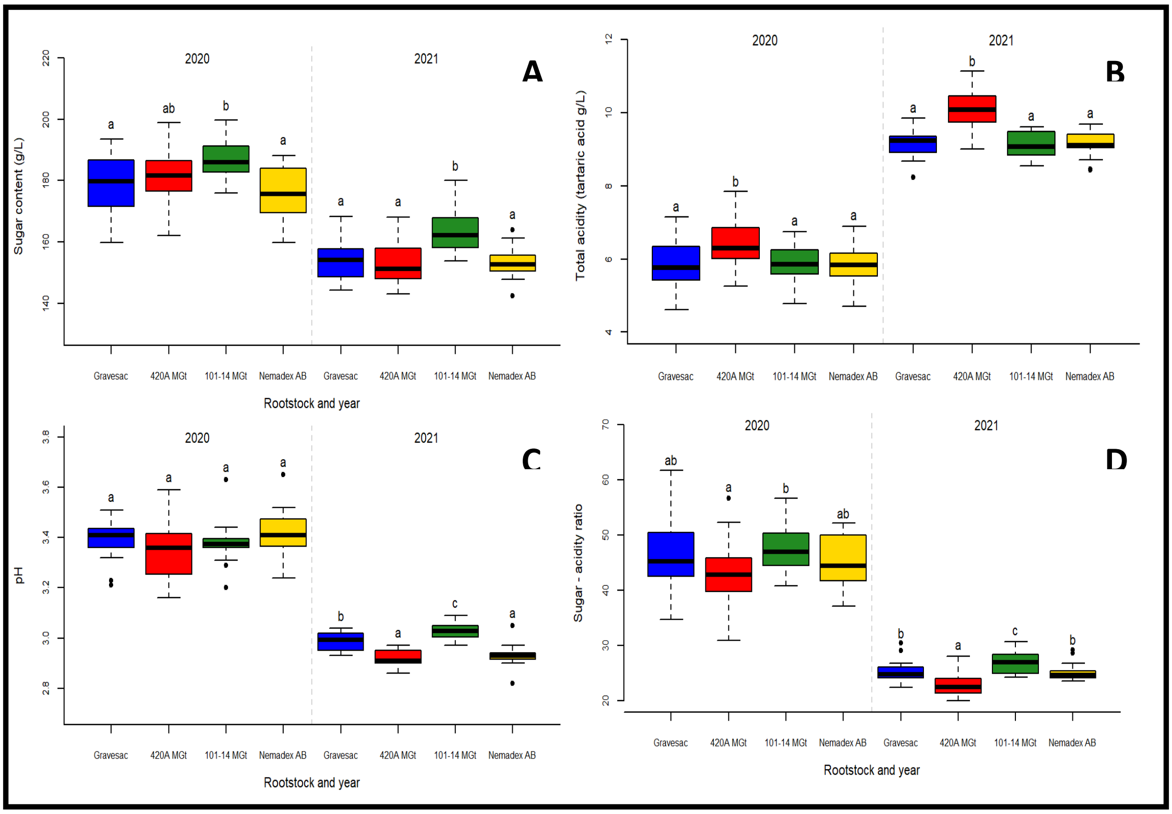

Figure 2. Technological maturity parameters; A-Sugar content in g/L, B-Total Acidity in g/L of tartaric acid, C-pH and D-Sugar/Acidity ratio; for each rootstock (Gravesac in blue, 420A MGt in red, 101-14MGt in green and Nemadex AB in yellow), in 2020 and 2021. The letters represent significant differences between rootstocks for the same year and were determined by a post-hoc Tukey test with $p < 0.05$.

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