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What's new with rootstocks?

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French research on rootstocks is based on two strategies: the creation of new rootstocks and the evaluation of existing rootstocks (GreffAdapt facility). The search for traits associated with drought tolerance has not yet been brought to a successful conclusion, but work is continuing with the emphasis on field experiments, measurement of $\delta^{13}C$, consideration of yield, and study of trait plasticity as a function of the scion and the water status.

How is French rootstock research organized?

While research on rootstocks is being carried out in Bordeaux by a single research team (UMR EGFV), it draws on collaboration with selection partners such as the Institut Français de la Vigne et du Vin, the Conservatoire du Vignoble Charentais, the Aude Chamber of Agriculture and the Comité Champagne.

All work being carried out on rootstocks has been positioned on the selection pyramid made up of three stages (Figure 1). The number of rootstocks that can move from one stage to the next is estimated at between 5 and 10.

Two strategies are being conducted in parallel: characterizing existing rootstocks and creating new rootstocks from controlled crosses. Work is in progress to collect the results of rootstock trials conducted in France and then subject them to statistical analysis as part of the PGvigne.net project funded by the National Vine Dieback Plan (PNDV). Such work could be extended to the European and international level.

The work being conducted by UMR EGFV is fundamental and applied at the same time. The research to identify the genetic regions controlling traits of interest should give results that can be applied in the long term. At the same time, the rootstocks from the crosses studied could prove to be efficient and be made available to professionals. The evaluation under way at the GreffAdapt facility, which is studying 55 existing rootstocks[1], may lead to new additions to the French catalog.

Rootstocks, an undeniable lever for adaptation to drought

Rootstocks represent a wide field of investigation and give rise to many questions from professionals in the sector. Some of the answers to winegrowers' questions can be found on the PlantGrape website (https://plantgrape.plantnet-project.org/en/porte-greffes) or the information portal created by UMR EGFV (https://www6.inra.fr/porte-greffe-vigne).

By way of introduction, it is crucial to bear in mind that the rootstock provides lasting resistance to phylloxera, which is still present in our vineyards.

Rootstock drought tolerance is well known empirically, but the mechanisms underlying it have not been clearly identified. The identification of marker traits for drought tolerance is nevertheless important, to characterize individuals that perform well as early as possible, at the seedling stage. To understand how the rootstock can affect drought adaptation, three categories of mechanism have been identified: first, the water extraction capacity; secondly, water transfer from the rootstock to the scion; and thirdly, water losses through the canopy and their regulation.

In studies of root system anatomy, drought-tolerant 110R has been shown to have a greater number of water-conducting vessel elements than drought-sensitive Riparia Gloire de Montpellier (RGM), regardless of the water status to which they were subjected[2].

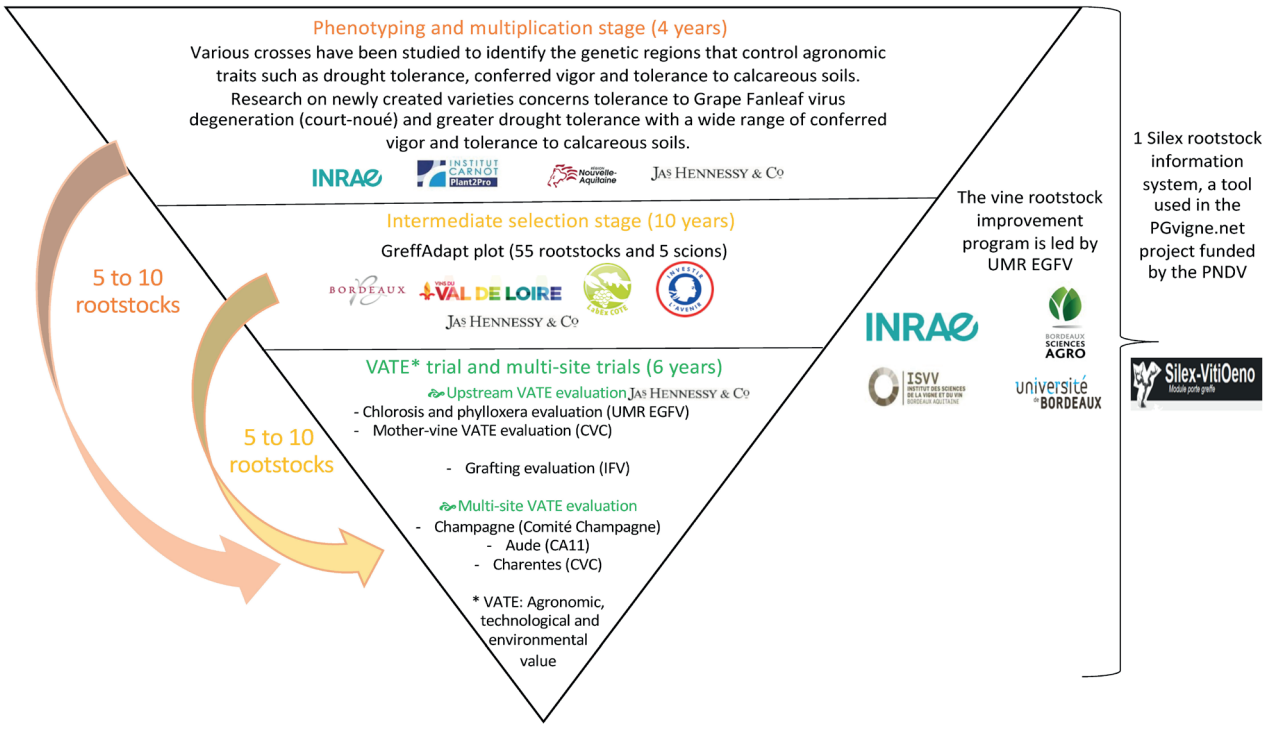

FIGURE 1. Positioning of the work carried out by UMR EGFV and its selection partners within the vine varietal selection pyramid.

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Despite significant rootstock × scion interactions, genetic regions involved in the control of root traits such as the number of roots – and the number of small, medium and large roots – have been identified[3]. In addition, vineyard studies have established that 1103P, described as drought tolerant, produces more roots in summer than 101-14 MGt, which is described as drought sensitive[4]. Work on the root system and the development of rapid measurement techniques are the focus of our attention.

Water transfer from the root system to the scion is often monitored using hydraulic conductivity measurements. Work by Hervé Cochard and Sylvain Delzon has shown that the susceptibility of the conducting vessels to embolism is well correlated with drought tolerance in many ligneous plants. For the grapevine, however, studies of a large panel of rootstocks have shown no direct and simple relationship between hydraulic conductivity measurements and known drought tolerance in the vineyard.

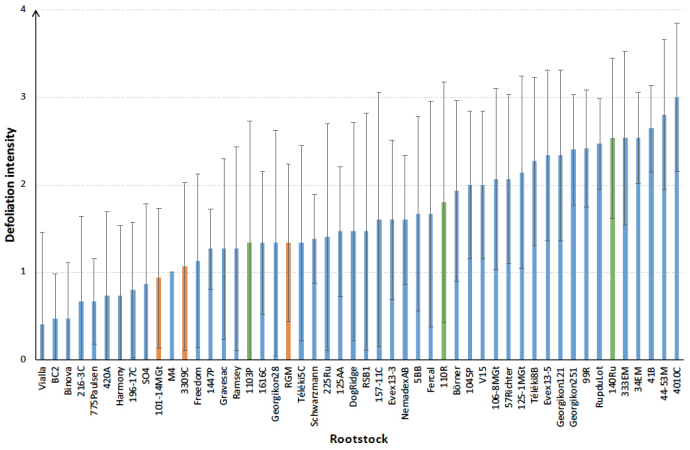

FIGURE 2. Defoliation intensity* rated on 27 July 2022 on Cabernet Sauvignon grafted with the various rootstocks** at the GreffAdapt facility, Bordeaux, France.

*Defoliation intensity rated from 0 to 4 (0: all leaves are green, 1: leaves of the first two nodes are yellow and/or dry, 2: leaves up to the fourth node are yellow and/or dry, 3: foliage is yellow or dry up to the lifting wires, 4: yellowing or defoliation affects leaves beyond the lifting wires)

** To serve as a benchmark, rootstocks described in the vineyard as being drought sensitive, 101-14 MGt, 3309C and RGM, are shown in orange, while rootstocks described in the vineyard as drought tolerant, 110R, 1103P and 140Ru, are shown in green.

The rootstock influences the conferred vigor and hence the size of the canopy, the diurnal and nocturnal transpiration of the scion[5], and also its regulation when subject to water deficit[6]. Genetic regions have also been identified but there are many of them and they explain only a small part of the observed variability. In other words, no major gene has been identified, in contrast to the case for resistance to downy mildew and powdery mildew. The work carried out at the GreffAdapt facility on the efficiency of water use, estimated by $\delta^{13}C$, demonstrates a rootstock effect but with no obvious link between the observed differences and empirical field knowledge. Work is continuing, in particular on maintaining yields under water deficit. The results from 2022 show that the current rootstocks performed well (Figure 2). Water conditions in 2022 were unusual, however, with high temperatures certainly leading to severe heat stress and water deficit that gradually set in during the growing season. The cumulative effects of heat and water stress over several similar years are still unknown. The conferred vigor results, using Cabernet Sauvignon as the scion, already provide a quantitative ranking (Table 1). These results may be surprising (RGM in the same conferred vigor class as SO4). Pruning weights confirm this ranking, obtained over three years at a facility where the vines are young (<7 years) and nitrogen status is not limiting.

TABLE 1. Ranking of conferred vigor for Cabernet Sauvignon grafted with the various rootstocks at the GreffAdapt facility, Bordeaux, France.

Vigor class (2019-2021 data)	Low <80 g/shoot	Moderate 80 g/shoot <- <120 g/shoot	High >120 g/shoot
Rootstock	161-49C (-) Nemadex AB (-)	110R (+) 140Ru (-) 3309C (+) 41B (+) Gravesac (+) RGM (+) SO4 (+) 57R (+) Georgikon 28 (+)	101-14 MGt (+) 1103P (+) 420A (+) Fercal (+) Rupestris du Lot (+) 157-11C (+) 225Ru (+) 775P (+) Evex 13-5 (+) Georgikon 121 (+) M4 (+) Ramsey (-) Vivet 15 (-)

GreffAdapt was planted in 2015-2016 at a density of 6,250 vines/ha on sandy-gravel soil with non-limiting nitrogen status. Three classes of yield on the vine were attributed: low (-) for a yield of less than 1 kg/vine, moderate (+) for a yield between 1 kg and 2 kg, high (++) for greater than 2 kg. The yield class for each rootstock is shown in brackets. Rootstocks in light blue are not listed in the French rootstock catalog.

The genetic resources are available and already partially characterized. Their evaluation should continue, with characterization of the adult stage of the GreffAdapt facility (2022-2025), and the search for combinations of traits correlated with tolerance to water deficit. ■

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