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Is xylem cavitation resistance a relevant criterion for screening drought resistance among *Prunus* species?

Hervé Cochard[a,*], S.Tete Barigah[a], Marc Kleinhentz[b], Amram Eshel[c]

[a]*UMR547 PIAF, INRA, Univ. Blaise Pascal, F-63100 Clermont-Ferrand, France*
[b]*Unité de recherche Espèces fruitières et vigne, INRA Domaine de la Grande Ferrade, France*
[c]*Department of Plant Sciences, Tel-Aviv University, Israel*

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Summary

Fruit trees are likely to suffer from the effects of severe drought in the future; however, sound criteria for evaluating the species' ability to survive these extreme conditions are largely missing. Here, we evaluated the feasibility of using xylem cavitation resistance as a tool for screening *Prunus* species for drought resistance. Ten different *Prunus* species were selected to cover a large range of water requirements, from hydrophilic to xerophilic types. Shoot cavitation resistance was evaluated with the new Cavitron technique. At this inter-specific level, cavitation resistance was related to species drought resistance, with xerophilic species being less vulnerable to cavitation. The Cavitron technique enabled species characterization that required a short time and small amounts of plant material. This technique could be used to evaluate the drought resistance of a limited number of fruit tree genotypes. Genotype screening on a larger scale, however, would likely require another approach. Out of a number of anatomical traits tested, a significant correlation was found between cavitation resistance and inter-vessel wall thickness across species. This anatomical trait is, therefore, suggested as a possible alternative to direct cavitation estimates and could be included as a screening criterion in breeding programs for drought resistance of *Prunus* genotypes.

Introduction

Drought conditions affect fruit tree production and are expected to become an increasingly severe problem based on future predictions for climate

*Corresponding author. Tel.: +33 4 73 62 44 71;
fax: +33 4 73 62 44 54.
E-mail address: cochard@clermont.inra.fr (H. Cochard).

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change and water availability. The sustainability of fruit production will depend on the identification of genetic material and plant characteristics that will contribute to future selection of drought-resistant fruit tree rootstocks and scions. Until recently, breeding programs for drought resistance focused on traits improving fruit yield under moderate drought conditions. However, during the intense drought episodes that have occurred recently in Europe, irrigation was limited in orchards and nurseries, and trees were subjected to exceptional water stress. This illustrates that the fruit trees may be threatened in the future by very drastic conditions. Tree resilience to drought is therefore an emerging aspect of drought resistance that should now be considered in breeding programs. This will necessitate the identification of new and relevant criteria for selecting more drought-resilient genotypes, as classical characters seem to be poor predictors of drought resilience.

A correlation has been found between drought resistance and xylem vulnerability to cavitation of a number of woody species (Salleo and LoGullo 1993; Cochard et al., 1996; Davis et al., 1998, 2002; Nardini et al., 2000; Vogt, 2001; Cordero and Nilsen, 2002; Sperry and Hacke, 2002; Lo Gullo et al., 2003; Pita et al., 2003; Tyree et al., 2003; Maherali et al., 2004). This suggests that species that are capable of maintaining functional xylem conduits under extreme drought conditions have a higher chance of survival, likely because they are able to extract water from the soil and thereby prevent dehydration of their leaves and meristems.

Determining the parameters of the xylem vulnerability curve (e.g., Alder et al., 1997) has been a tedious and time-consuming task. Therefore, only a small number of samples could have been analyzed and the method could not be applied routinely in selection and breeding programs. Recently, we developed a new measuring technique that makes use of a specially designed measuring rotor attached to a modified centrifuge (Cochard et al., 2005). This new 'Cavitron' technique has a number of advantages over the previous techniques in several key aspects. Unlike the standard technique introduced by Sperry et al. (1988), an entire vulnerability curve can be obtained on one stem segment with the new apparatus (typically a 0.30 m long piece of the tree shoot). This considerably lowers the quantity of plant material needed to record the cavitation resistance of a given genotype. Therefore, this allows the characterization of young plants, a decisive aspect for breeding programs of tree genotypes. The rapidity of the new technique is also a major advantage. The construction of an entire vulnerability curve required about 1 week for one genotype with the Sperry et al. (1988) technique. With the new technique, this time can be reduced to less than 1 h. A relatively large number of genotypes can now be screened.

In this study, we focused on different species of the genus *Prunus*, which contains many of the most economically important fruit trees such as peaches, plums, apricots, cherries, and almonds. The first objective was to use the Cavitron technique to determine the vulnerability of the shoot of these species to cavitation, and in a number of wild *Prunus* species that could potentially be used in inter-specific crosses to enhance the drought resistance of *Prunus* rootstocks. A second objective was to identify more accessible anatomical traits correlated with cavitation resistance that could be used for screening *Prunus* genotypes on a much larger scale.

Material and methods

Plant material

Measurements were conducted on 10 different *Prunus* species. Four wild and six cultivated species were studied. *Prunus padus* L. (Bird Cherry) was collected in a humid area in the Auvergne Volcano Park. *P. avium* (L.) L. (Wild Cherry), and *P. spinosa* L. (Blackthorn) were sampled in a more mesophilic site from the same park. *P. mahaleb* L. (Mahaleb Cherry) was growing in a xerophilic site in the Limagne valley in the vicinity of the INRA-Clermont Campus. *P. cerasifera* Ehrh. (Myrobolan Plum), *P. cerasus* L. (Sour Cherry), *P. persica* (L.) Batsch (Peach), *Prunus domestica* L. (Plum), *P. armeniaca* L. (Apricot), and *P. dulcis* (Mill.) D.A. Webb = *amygdalus* Batsch (Almond) cultivated in the Limagne Valley, were collected from the INRA-Clermont orchards.

One-meter-long branches were sampled between June and July 2006 from the sun-exposed part of different trees for each species and brought to the laboratory in plastic bags (to minimise water loss), where they were analyzed for cavitation resistance on the same day.

Xylem vulnerability to cavitation

Xylem cavitation was assessed with the Cavitron technique (Cochard et al., 2005), a technique derived from the centrifuge method of Alder et al. (1997). The principle of the technique is to use centrifugal force to increase the water tension in a xylem segment and, at the same time, measure the decrease of its hydraulic conductance. The curve of percentage loss of xylem conductance (PLC) versus xylem water tension represents the sample vulnerability to cavitation. Vulnerability curves were determined on four–five different samples for each species. Samples were 0.28 m long and cut in air from the main axis of each branch.