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# Effect of water stress “memory” on plant behavior during subsequent drought stress

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ABSTRACT

Frequency of extreme drought events are expected to increase due to climate change. Perennials are increasingly exposed to recurrent drought during their life span. The aim of the present work was to study the effect of recurrent droughts on the behavior of *Vitis vinifera* under water stress. Sangiovese and Montepulciano vines were exposed to severe drought stress for 4 years (WS-S). A dry-down experiment was carried out to compare their behavior with a set of vines kept at 90% field capacity during the whole seasons in the previous 4 years (WW-S). WS-S vines had higher transpiration and stomatal conductance than WW-S vines. Net photosynthesis was almost unaffected by the treatment. Stomatal conductance was higher at more negative $\Psi_{stem}$ in WS-S vines than in control vines. Leaf petiole percentage loss of hydraulic conductance, measured during water stress, was higher in WS-S than in WW-S vines. Results indicate that previous water stress can lead to less conservative plant strategy toward water loss and decreased water use efficiency. This behavior seems to be coordinated with the different stomatal response to decreasing water potential that caused a reduction of xylem hydraulic safety margin in WS-S vines in comparison with WW-S vines.

## 1. Introduction

Drought event frequency and severity are expected to increase in the near future as result of the decrease of regional precipitation and the increase in evapotranspiration driven by global warming (Sheffield and Wood, 2008; Sheffield et al., 2012; Dai, 2010). Changes in the global water cycle in response to the warming over the 21st century will not be uniform, and natural droughts are expected to set in quicker, to become more intense, and to last longer (Trenberth et al., 2014). Among all the natural hazards, drought ranks first in terms of the number of people directly affected (Wilhite, 2000). Taking into account agriculture, drought, under vulnerable situations, can endanger food security with cascade effects on economy, geopolitics and society (Grayson, 2013). Thus, the understanding of how plants and crops adapt and behave under this scenario is a goal of primary importance to improve agricultural performance towards recurrent droughts and to address the challenges of climate change, consequently.

Drought endangers the survival of both annual and perennial species, though annual species have a larger number of options to withstand and adapt to climate change than perennial species. While annual species can change their phenotype according to changing climatic condition by evolution or plasticity, in perennials, and in particular in tree species, climate change adaptation by evolution is largely unavailable due to their relatively long reproduction cycle (Franks et al., 2014). Thus, considering forest species, the fate of tree species in changing environment is mainly to persist through migration, or to adapt through phenotype plasticity, or to disappear (Aitken et al., 2008). Focusing on agricultural tree crops, there are many socio-economic factors (i.e. long re-establishment periods, closeness to processing plants, availability of skilled hand labor, and accessible markets) that make production area change difficult (Glenn et al., 2014). For instance in grapevine (*Vitis vinifera* L.), the most important tree crop in the world in terms of value (FAOSTAT, 2018), the temperature and water deficit increases in the next centuries are projected to make Mediterranean basin (currently the most important cultivation area in the world) progressively unsuitable for cultivation with consistent socioeconomic impact on that region (Moriondo et al., 2013). *V. vinifera* is also one of the most important model species for studying drought effect in tree species (Lovisolo et al., 2010), and a large number of studies describe the effect of water deficit on grapevine physiology and on the ability of recovery after drought (for a review see Chaves et al., 2010 and Lovisolo et al., 2010). When water stress occurs, plant growth and overall carbon fixation are reduced with significant negative consequences on plant productivity and, in extreme cases, on plant survival

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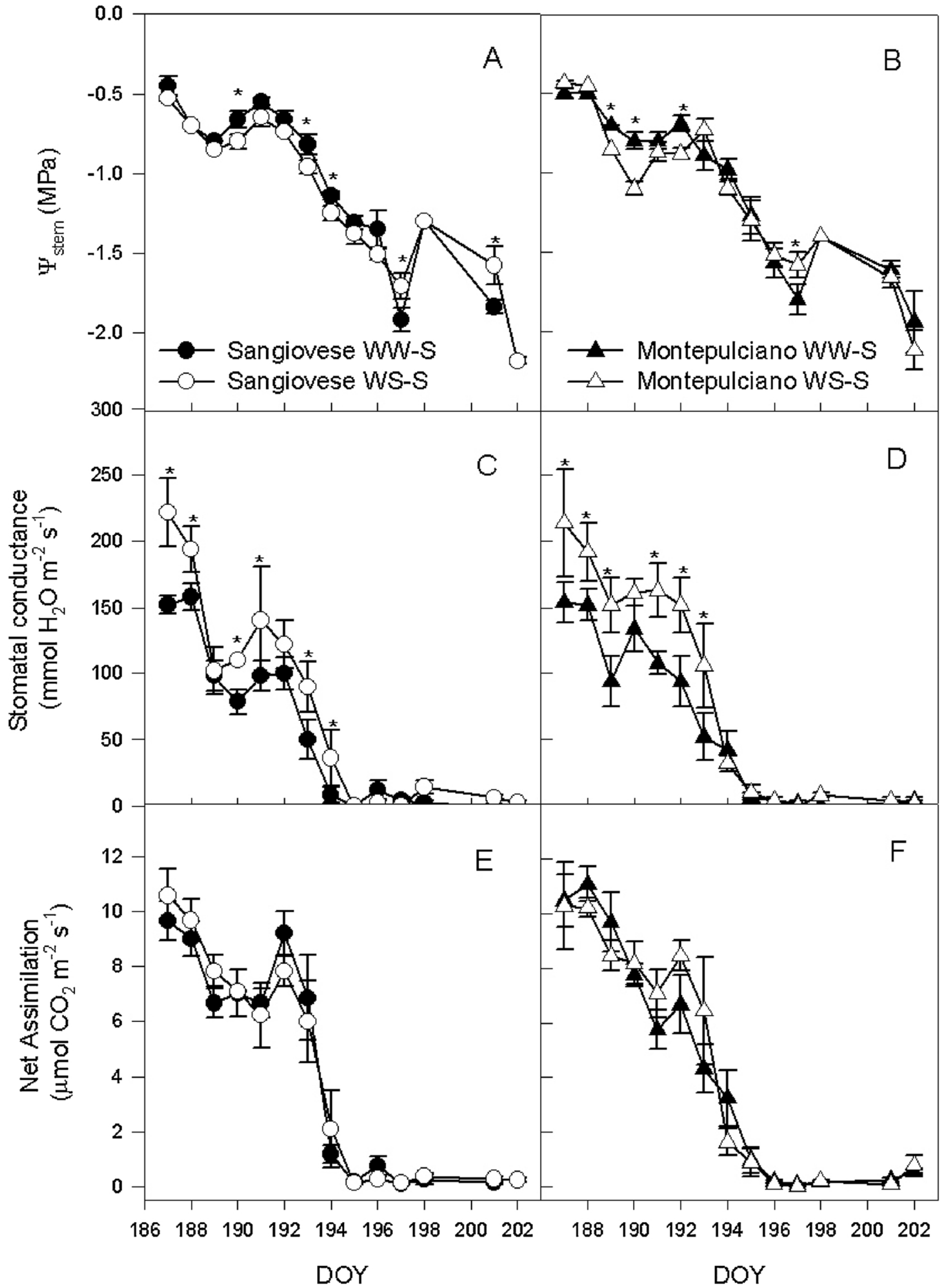


**Fig. 1.** Trend of stem water potential (A, B), Stomatal conductance (C, D) and Net assimilation (E, F) in Control and WS vines of Sangiovese (A, C, E) and Montepulciano (B, D, F) during the experiment (DOY, days of the year). Points marked with * are different per P = 0.05 (t test).

(Palliotti et al., 2014). When water availability in the soil becomes critical for vines, stomatal closure acts as an early response, buffering the drop of xylem water potential and the consequent risk of massive xylem embolism and catastrophic hydraulic failure (Jones and Sutherland, 1991; Tyree and Sperry, 1989). The onset of stomatal closure coincides with the reaching of critical tension (i.e. water potential) in the stem xylem (Salleo et al., 2000; Choat et al., 2012). Stomatal functionality appears to be regulated primarily by hydraulic signals (Nardini and Salleo, 2000; Franks, 2004), although, under water stress conditions, stomata responds also other to chemical or hormonal signals produced by the dehydrating roots. The most important hormonal signal in this regard is absisic acid (ABA), which has been very well observed in dehydrating roots and circulating in plants under water deficit conditions (Chaves et al., 2002). ABA is thought to produce its effect through it's interaction with other chemicals like jasmonic acid (JA), cytokinins, auxin and ethylene (Tuteja and Sopory, 2008). They produce their effect through ion exchange, cytoskeletal reorganization, metabolite production, modulation of gene expression and post-translational modification of proteins (Sarwat and Tuteja, 2017). ABA and JA are positive regulators of stomatal closure, auxins and cytokinins are negative regulators and the role of ethylene dependent on the tissue and its condition (Daszkowska-Golec and Szarejko, 2013).

Drought effects (in particular water stress) on the physiological behavior of annual and perennial species have been widely investigated. Nevertheless, scant information is available on the behavior of perennial species subjected to recurrent drought. Trees in areas vulnerable to drought are exposed to drought stress almost every year, and this could naturally prime tree response to drought. In fact, plant stress 'memory', i.e. the structural, genetic, and biochemical modifications that have occurred because of stress exposure and which make