Scientia Horticulturae 199 (2016) 158–162

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Short communication

Drought tolerance of three olive cultivars alternatively selected for rain fed or intensive cultivation

Yizhar Tugendhaft[a,b], Amir Eppel[a], Zohar Kerem[b], Oz Barazani[c], Alon Ben-Gal[d], Joachim W. Kadereit[e], Arnon Dag[a,*]

[a] Institute of Plant Sciences, Agricultural Research Organization, Gilat Research Center, 85280, M.P. Negev 2, Israel
[b] Institute of Biochemistry, Food Science, and Nutrition, Robert H. Smith Faculty of Agriculture, Food and Environment, The Hebrew University of Jerusalem, Rehovot, Israel
[c] Institute of Plant Sciences, Israel Plant Gene Bank, Agricultural Research Organization, Bet Dagan, Israel
[d] Institute of Soil Water and Environmental Sciences, Agricultural Research Organization, Gilat Research Center, 85280, M.P. Negev 2, Israel
[e] Institut für Spezielle Botanik und Botanischer Garten, Johannes Gutenberg-Universität Mainz, D-55099 Mainz, Germany

ARTICLE INFO

Article history:
Received 1 October 2015
Received in revised form
21 December 2015
Accepted 24 December 2015
Available online 4 January 2016

Keywords:
Drought stress
Leaf water potential
Stomatal conductance
Net photosynthesis

ABSTRACT

Physiological drought response was evaluated for two olive cultivars commonly grown under rain fed conditions ('Souri' and 'Picual') and another selected for intensive, irrigated cultivation ('Barnea'). 'Souri' is a traditional local Israeli cultivar, 'Picual' originated in Spain and 'Barnea' is a modern Israeli cultivar.

Trees in pots were alternatively provided well irrigated conditions (100% FC, field capacity) or allowed to dry, first to 33% FC and then to 10% FC. Under conditions of greatest water availability, the 'Barnea' cultivar had the highest stomatal conductance and net photosynthesis, significantly higher than that found in 'Souri'. Stomatal conductance and leaf water potential of 'Souri' and 'Picual' at 33% FC were not affected relative to the well irrigated treatment but decreased significantly at 10% FC. Photosynthetic parameters of 'Souri' and 'Picual' were not affected by water stress. Stem growth was also not affected by drought in 'Souri' but was reduced at 10% FC in 'Picual'. In contrast, the 'Barnea' showed higher sensitivity to low water availability with stomatal conductance and net photosynthesis reduced at 33% FC and sharp decreases in these and leaf water potential occurring at 10% FC. At 10% FC 'Barnea' trees showed stem shrinkage, a phenomenon not observed in the other cultivars. These results suggest a tradeoff between selection for suitability in intensively irrigated orchards and tolerance to drought.

1. Introduction

Olive (*Olea europaea* L.) is an important tree crop in countries with Mediterranean climate (Loumou and Giourga, 2003) whose cultivation in the eastern Mediterranean basin commenced more than 6000 years ago (Kaniewski et al., 2012). Olive fruits and oil are important to the Mediterranean diet and are considered beneficial to human health (Psaltopoulou et al., 2004). The olive tree is well adapted to tolerate drought, and can survive and produce fruits with little available water (Angelopoulos et al., 1996; Girón et al., 2015; Torres-Ruiz et al., 2015), a trait that is associated with the species' ability to maintain photosynthesis and transpiration at low water potential (Chartzoulakis et al., 1999; Sofo et al., 2007). Olive varieties have been shown to vary in their drought tolerance (Connor, 2005; Torres-Ruiz et al., 2013) due to differences in leaf structure and morphology, stomatal conductance and water use efficiency (Bosabalidis and Kofidis, 2002; Guerfel et al., 2009).

Since its domestication, the olive tree has been cultivated as a rain fed crop. Two examples of traditional olive cultivars which are used today in rain fed agriculture are 'Souri' and 'Picual'. 'Souri' dominates rain fed plantations across Israel and the Palestinian Authority (Barazani et al., 2008; Barazani et al., 2014). 'Picual' is a Spanish cultivar grown in arid areas of Andalucía in rain fed orchards and is considered to be drought tolerant (Shaheen et al., 2011). Over the last decades, with a growing demand for olive oil and improvement of olive production and harvest technologies, olive irrigation has proliferated (Connor, 2005; Vossen, 2007; Torres-Ruiz et al., 2015). 'Barnea' is a modern cultivar bred for high yield under intensively irrigated conditions (Lavee, 2011).

Drought stress limits tree growth worldwide, determining structure and function of many agricultural and forestry systems (McDowell, 2011; Cocozza et al., 2015). Historical orchard cultural

* Corresponding author.
E-mail address: arnondag@agri.gov.il (A. Dag).

http://dx.doi.org/10.1016/j.scienta.2015.12.043
0304-4238/

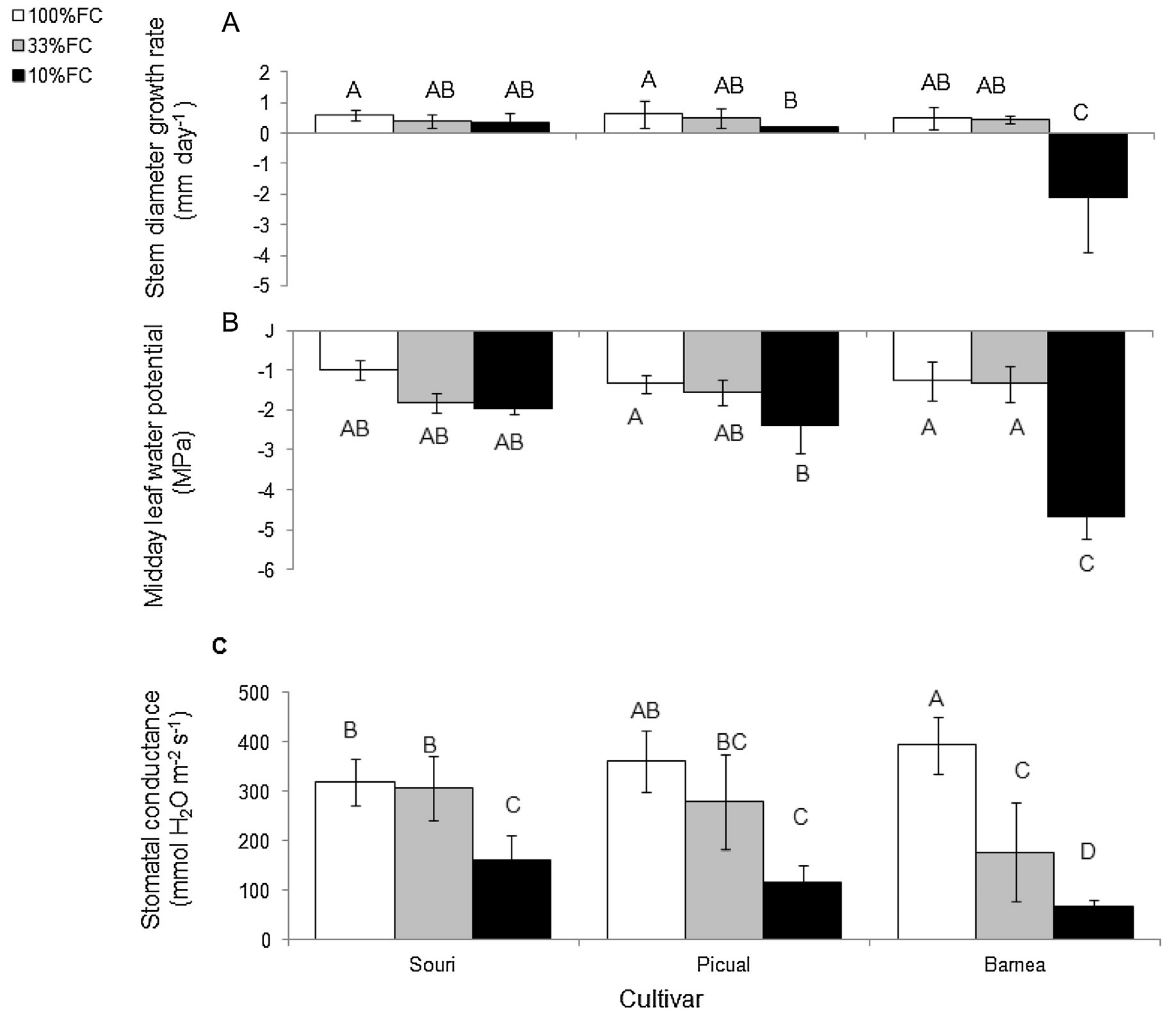

Fig. 1. Stem diameter (A), midday leaf water potential (B) and stomatal conductance (C) for the olive cultivar—irrigation treatment combinations. Different letters indicate significant differences between combinations of cultivar/treatment. $n = 4$, Error bars represent standard deviation.

practices have largely determined the genetic diversity that exists today in olives. The Mediterranean region, an arid 'hot spot' with recurring water shortages, will likely be subjected in the future to decrease amounts of precipitation and prolonged drought periods (Dai, 2011), creating conditions under which water deficit might become critical even for drought-adapted species. Therefore understanding difference in drought tolerance between olive cultivars might be useful for sustainable agriculture production and water use.

2. Materials and methods

Semi-hardwood cuttings of 5 mm diameter were taken from mother plants of 'Picual', 'Barnea' and 'Souri'. The cuttings of 'Barnea' and 'Picual' were taken from trees growing in an experimental orchard at the Gilat Research Center, Israel. The cuttings of 'Souri' were taken from an old rain fed plantation near Amazia, south of Jerusalem, Israel where the mother trees were identified as 'Souri' in a previous study (Barazani et al., 2014). The cuttings were rooted as described previously (Dag et al., 2012), and were inoculated with mycorrhiza mix prior to planting (Dag et al., 2009). Plants were grown in 3 L pots for one year in a greenhouse, and upon reaching a height of 80 cm, were transplanted into 8 L pots filled with commercial potting media composed of coconut fibers, peat and tuff (Deshanit, Israel). Plants were grown in four block repetitions, each block containing at least two plants of each of the three cultivars.

Field capacity (FC) was determined gravimetrically by immersing a sample of the rooting media in water for 24 h, followed by draining and drying at 105 °C for 24 h. Media weights were determined before and after drying, and 100% FC was obtained as volumetric water content of 80%.

The experimental drought period started when trees were one year old at which time the media filled pots were occupied considerably by roots. Moderate drought conditions were imposed on half of the plants for 11 days, until root media water content decreased to 33% FC (volumetric water content of 26%). Severe drought conditions were imposed by withholding water for an additional week, until water content decreased to 10% FC (volumetric water content of 8%). During this period the other half of the plants were irrigated to return measured daily evapotranspiration (100% FC). The drought period lasted for a total of 18 days.

There were 4 replicates for each treatment in each cultivar. During the time of the experiment, average relative humidity was 65%, with average daily maximum and minimum values of 92% and 30%, respectively. Average temperature in the greenhouse was 27 °C, with average daily maximum and minimum values of 33 °C and 23 °C, respectively. Average daily maximum incoming photosynthetic active radiation (PAR) was 600 (μmol photon m^{-2} s^{-1}).

Stem diameter was measured using an electronic micrometer, and the difference between two consecutive measurements was