Influence of rootstocks on pistachio (Pistacia vera L.) water relations

Alfonso Moriana
Universidad de Sevilla

Mireia Corell
Universidad de Sevilla

Arturo Torrecillas
Spanish National Research Council

David Pérez López
Universidad Politécnica de Madrid

XIII Simposio Hispano-Portugués de Relaciones Hídricas en las Plantas

"Aprendiendo a optimizar el uso del agua en las plantas para hacer de nuestro entorno un ambiente más sostenible"

LIBRO DE RESÚMENES

(ISBN 978-84-8081-525-3)

Pamplona, 18 – 20 de octubre de 2016

Influence of rootstocks on pistachio (*Pistacia vera* L.) water relations

Memmi, H.[1], Centeno, A.[2], Moriana, A.[3], Corell, M. [3], Torrecillas, A.[4], Pérez, D. [2]

[1] CA "El Chaparrillo". IRIAF. Ciudad Real.
[2] Universidad Politécnica de Madrid. Av. Complutense s/n. Madrid. ana.centeno@upm.es
[3] Universidad de Sevilla. C/ S. Fernando, 4. Sevilla.
[4] CEBAS-CSIC. Campus Universitario de Espinardo. Espinardo. Murcia.

ABSTRACT

Pistachio potted plants budded on three different rootstocks were submitted to water stress during 28 days with the aim of studying their water relations and physiological responses. Water stress resulted in an accented drop of stem water potential and leaf conductance. Nonetheless, pistachio plants showed a great capacity to contrast drought effects by the recourse to osmotic adjustment mechanisms. Regarding rootstocks, UCB-I results being the less adapted rootstock to conditions of water stress.

INTRODUCTION

The preference of a rootstock against another would be closely related to its drought tolerance which could be defined by its capacity to improve growth in limited water conditions (Kramer and Boyer, 1995).The improvement of growth under water stress seems to be mostly dependent on turgor maintenance (Bradford and Hsiao, 1982). This mechanism is defined as osmotic adjustment. Previous evidence of the occurrence of osmotic adjustment in pistachio has been reported (Gijon et al., 2011) in response to water stress but there is no evidence of the fact that different rootstocks could affect differently the osmotic adjustment at the scion level. Thus the aim of this work was to study the response of pistachio plants to water stress by the means of water relation and to analyze the possible different responses of three widely used rootstocks.

MATERIAL AND METHODS

Site description and experimental design

The experiment was conducted during the summer of 2013 at "La Entresierra" Research Station, Ciudad Real, Spain. Thirty pistachio plants of two-year old (P. vera L. cv. Kerman) budded onto three different rootstocks, P. *atlantica Desf*., *P. terebinthus L.*, and UCB-I were used. The experiment took place from "Day Of the Year" (DOY) 178 until DOY 246 and consisted in the implementation of 28 days of water stress to the half of pots. The experimental design was a completely randomized factorial design with 5 replicates. The main factor was the rootstock and the secondary factor was irrigation. The different combination of the two factors will be named as follows:

P. atlantica-Control (AC); P. atlantica-Stress (AS); P. terebinthus-Control (TC); P. terebinthus-Stress (TS); UCBI-Control (UCB-C) and UCBI-Stress (UCB-S).

Measurements

Soil moisture measurements were taken at 10 and 20 cm depth with a portable capacitance probe (Diviner, 2000, Sentek Pty. Ltd., Australia) placed approximately 15 cm away from the stem.Stem water potential (Ψ_x) measurements were made weekly in all plants. At the same time abaxial leaf conductance (g_l) was measured with a steady-state porometer (LICOR-1600, UK) between 12:00 and 14:00 local time. Pressure–volume (P–V) curves were performed at the end of stress period. The parameters derived from each curve were: osmotic potential at full turgor ($\Psi_{s,100}$), osmotic potential at zero turgor ($\psi_{s,0}$), relative water content at zero turgor (RWC_0), percentage of the symplastic water content (R), tissue elasticity (E_o), osmotic adjustment index (OA_{index}) and the breaking point (BP) (Turner, 2006). An ANOVA was done and means were compared using the test of Tukey, with a significance $P < 0.05$.

RESULTS

Water relations

Figure 1 shows the pattern of Ψ_x throughout the experiment. Ψ_x for stressed plants ranged between -0.79 and -3.4 MPa and the effect of water stress was not detected until DOY 210, ten days after the implementation of stress. From this date until the last day of stress, Ψ_x was significantly different between control plants and stressed plants. Independently from irrigation treatment, PA and UCB-I kept significantly higher Ψ_x trend than PT plants except on DOY 179, 210, 214, 228 and 246 in which a same tendency was preserved but differences were not significant. On DOY 210, AS had the highest values followed by UCB-S and TS being respectively -1.33 MPa, -1.61 MPa, and -1.66 MPa. On DOY 221, no statistical difference was seen between AS and UCB-S but they were significantly different from TS (Figure 1). On the last day of stress, no difference was perceived between rootstocks dropping all to a similar level of Ψ_x and reaching the lowest values during the experiment 28 days after stress implementation. Leaf conductance (g_l) ranged between 36 and 338 mmol m^{-2} s^{-1} in stressed plants (Figure 1). Until DOY 214, plants were not grouped into irrigated and stressed plants, and maximum leaf conductance was randomly distributed between irrigated and stressed plants. On DOY 221, UCB-S and AS had a similar gl and were significantly different from TS being respectively 174 mmol m^{-2} s^{-1}, 149.9 mmol m^{-2} s^{-1} and 90.9 mmol m^{-2} s^{-1}. Water stress decreased RWC_0 in 8 %, $\Psi_{s,100}$ in 0.3 MPa and $\Psi_{s,0}$ in 0.78 MPa. No significant differences were found concerning the rest of parameters.Regarding rootstocks, the three rootstocks showed a significant difference in $\Psi_{s,100}$, E_o and the BP. $\Psi_{s,100}$ and BP were significantly higher in UCB-I and PT showed a significant difference compared to both other rootstocks in the Eo (Table 1).

DISCUSSION

Water stress results in a decrease of stem water potential and a partial closure of stomata (Figure 1). Gijón et al., (2010) applied a stress of 14 days to potted pistachio plants under the same conditions and obtained similar results than the obtained in this work (similar gl values). So, a longer period of stress was not translated in a greater drop of leaf conductance. The maintenance of stomatal opening at lower water potential was reported to be a result of an osmotic adjustment mechanism (Turner and Jones, 1980). A drop of Ψ_x from -0.79 MPa to -3.4 MPa in 28 days was accompanied by a decrease of $\Psi_{s,100}$ by 0.3 MPa and $\Psi_{s,0}$ by 0.78 MPa (Table 1). This mechanism allows the leaves to maintain turgor at lower water potentials, thereby increasing the drought tolerance of the plant. The water potential at turgor loss has been often used to assess physiological drought tolerance and can consequently situate the degree of tolerance of pistachio to water stress among other species. Comparing the present values with other fruit tree species showed that the decrease in $\Psi_{s,0}$ in pistachio is lower than that reported for stressed olive trees (Rieger, 1995) but higher than that reported for citrumelo (Rieger, 1995) and apple (Fanjul and Rocher, 1984) situating then pistachio as less drought tolerant species than olive but more tolerant than the other mentioned ones.

Water stress affected gl in all rootstocks. Nonetheless, PT showed a somewhat higher stomatal control than the other rootstocks. This result seems contradictory with the results obtained from the P-V curves. PT and PA showed a lower $\Psi_{s,100}$ than UCB-I. Considering $\Psi_{s,100}$ as an index of physiological drought tolerance, PT and PA seems to improve their drought tolerance by making their $\Psi_{s,100}$ more negative. These results are in accordance with the previous confirmations that UCB-I is less adapted to water stress than the other mentioned rootstocks (Ferguson et al., 2005). Regarding the difference between PT and PA, the first rootstock was characterized by an increased Eo. Highly elastic cells have been reported as a trait aiding to maintain turgor in some cases. Nevertheless, results are not clear since the increase and the decrease of elasticity have been reported to be linked to drought tolerance (Turner and Jones, 1980).In this work, no difference in the OA_{index} was found but the three rootstocks seem to be able of a full osmotic adjustment regarding BP which is an indicator of drought resistance. UCB-I showed a lower break point than the other rootstocks confirming the previous results (Table 1).UCB-I is known to be the most vigorous rootstock, PA with a median vigor and PT as the smallest (Ferguson et al., 2005). This fact presents contrast with the previous results if osmotic adjustment is considered as the major mechanism driving scion growth. Then, above osmotic adjustment, different mechanisms seem to be operating between rootstock and scion.

CONCLUSIONS

Pistachio plants were able to maintain turgor by different variable emanating from a high osmotic adjustment capacity. Confirming previous findings, UCB-I seems to be the less adapted rootstock to water stress conditions compared to *Pistacia terebinthus* and *Pistacia atlantica*.

REFERENCES

Fanjul L. & Rosher P.H. (1984). Effects of water stress on internal water relations of apple leaves. *Physiol. Plant. 62*, 321-328.

Ferguson L., Sanden B., Grattan S., Epstein L., Krueger B. (2005). Pistachio rootstocks. In Ferguson, L., Beede, R.H., Freeman, M.W., Haviland, D.R., Holtz, B.A., Kallsen, C.E. (Eds). *Pistachio Production Manual*. University of California, 67-73.

Gijón MC, Giménez C, Pérez D, Guerrero J, Couceiro JF, Moriana A. (2010). Rootstock influences the response of pistachio (*Pistacia vera* L. cv Kerman) to water stress and rehydration. *Sci. Hortic. 125,* 666-671.

Rieger M. (1995). Offsetting effects of reduced root hydraulic conductivity and osmotic adjustment following drought. *Tree Physiol.15*, 379-385.

Turner NC & Jones MM. (1980). Turgor maintenance by osmotic adjustment: a review and evaluation. In: Turner NC and Kramer PJ (Eds). *Adaptation of plants to water and high temperature stress,* 87-104.

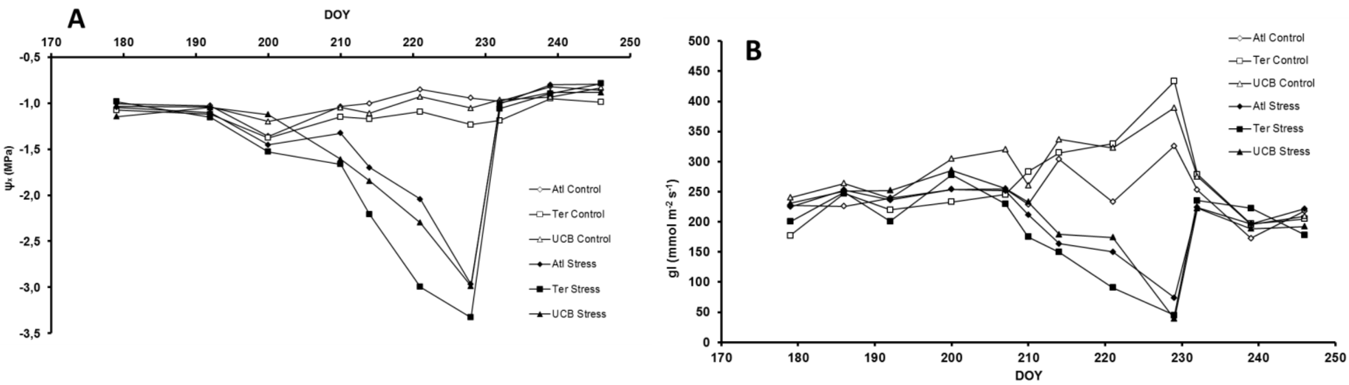

Figure 1. Stem water potential (Ψ_x) (A) and leaf conductance (gl) (B) course during the experiment. Each point is the average of 5 replicates.

Table 1. Pressure–volume curve parameters obtained control, stressed treatment and for each rootstock. Each value is the average of 3 data. Different subscript letters mean significant differences between treatments (Tukey test; $P < 0.05$).

Irrig-trt/rtstk	RWC_0(%)	$\Psi_{s,0}$(MPa)	$\Psi_{s,100}$(MPa)	E_o	R (%)	a	b	BP(MPa)	OA_{index}
Control	88±0**a**	-2.39±0.09**a**	-1.91±0.07**a**	14.90±3.75	34±6	0.39±0.06	-0.59±0.07	-1.49±0.10	0.40±0.06
Stress	80±1**b**	-3.17±0.18**b**	-2.21±0.08**b**	11.93±3.46	34±4	0.52±0.05	-0.66±0.06	-1.72±0.09	0.34±0.05
PT	82±3	-2.98±0.38	-2.15±0.13**a**	25.21±5.11**a**	30±9	0.56±0.08	-0.75±0.08	-1.79±0.13**b**	0.27±0.08
UCB	86±1	-2.44±0.12	-1.82±0.06**b**	7.50±1.51**b**	43±5	0.28±0.06	-0.48±0.07	-1.34±0.11**a**	0.51±0.06
PA	82±1	-2.92±0.13	-2.20±0.09**a**	7.54±2.43**b**	28±3	0.52±0.07**a**	-0.66±0.08	-1.70±0.12**b**	0.33±0.07