Influence of saline drip irrigation on root bio- and necromass and specific root area of mature olive trees

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Introduction

Olive is one of the most economically valuable tree species in the Mediterranean countries. Olive trees are highly drought and moderately salt tolerant. However, salt tolerance varies strongly between varieties. Although roots are the first organs to be affected by salt stress, most research on salt tolerance has focussed on aboveground organs but neglected responses of the roots.

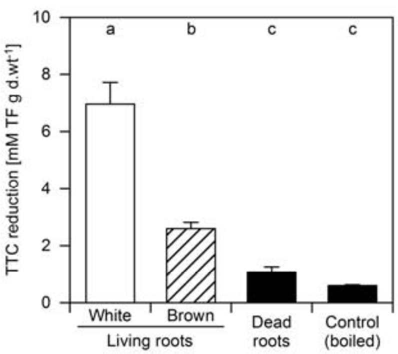

Fig. 1 Reduction of Tetrazolium-Chloride in living root tissues to test for applied visual sorting criteria into living / dead root segments (mean+SE, P<0.05, n = 5-7).

Material and Methods

Two drip-irrigated varieties of 11 yrs-old olive (*Olea europaea* L.) trees, 'Barnea' and 'Proline', considered as highly tolerant and sensitive to salinity respectively, were examined in the Negev desert, Israel. Three levels of salinity, 1.2 dS m^{-1} (Ctrl), 4.2 dS m^{-1} (Moderate salinity) and 7.5 dS m^{-1} (Severe salinity) were applied on 'Barnea' trees while 'Proline' variety was treated with 1.2 and 4.2 dS m^{-1}. 12 soil cores were taken down to 50 cm, to determine root bio- and necromass, water content and salinity. A tetrazolium test was used to confirm the applied criteria of root sorting into living and death (Fig. 1). Coarse root (diameter 3-7 mm) sap flow rates were determined with miniature heat-balance sap-flow gauges after Senock and Ham. The Xylem sap osmolality was measured with an osmometer (Wescor, USA) and the specific root area was determined with a flat bed scanner and WinRhizo (Regent, Canada).

Key Questions

i) Does the root biomass of salt sensitive olive variety 'Proline' reacts differently to salinity than that of salt-tolerant 'Barnea' variety?
ii) Do 'Proline' and 'Barnea' varieties' specific root areas react differently to salt stress?
iii) Does salinity reduce the sap flow densities of coarse roots?
iv) Do salt tolerant 'Barnea' trees possess a higher salt exclusion capacity than salt sensitive 'Proline' variety?

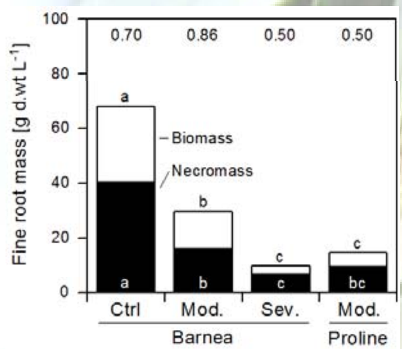

Fig. 2 Fine root bio- and necromass of 'Barnea' and 'Proline' varieties, 15 cm distance to drip line and to a depth of 50 cm. Trees were irrigated either with fresh (Ctrl), moderate (Mod.) or severe (Sev.) saline water. The bio:necromass ratio is given at the top edge (means; P<0.05; n = 5).

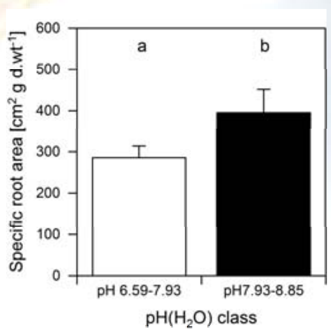

Fig. 3 Specific root area of 'Barnea' variety in soil patches with 2 different pH values (means; P<0.05; n = 77).

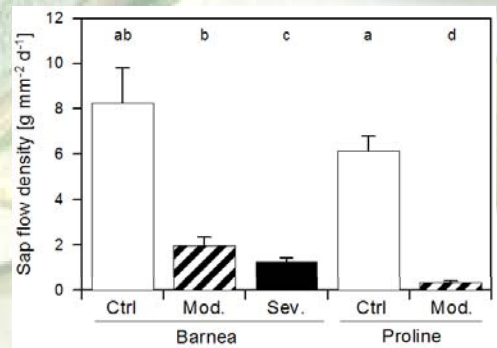

Fig. 4 Daily means of coarse root (d = 3-7 mm) sap flow densities of olive varieties 'Barnea' and 'Proline' in the period 12.-21. January 2009. Trees were irrigated either with fresh (Ctrl), moderate (Mod.) or severe (Sev.) saline water (mean+SE, P<0.01, n = 5-7).

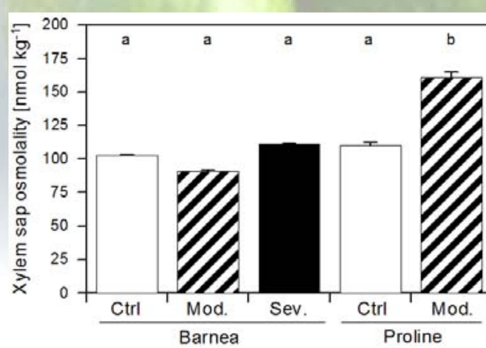

Fig. 5 Xylem sap osmolality, measured in branches of 'Barnea' and 'Proline' trees, grown either under control (Ctrl), moderate salinity (Mod.) or severe salinity (Sev.; mean+SE, P<0.05, n = 5).

Table 1 Three-way, weighed GLM for biotic, abiotic and spatial effects on fine root biomass and specific root area of olive varieties 'Barnea' and 'Proline'. Fine root biomass was weighed to stem basal area of the closest tree.

Source*		Fine root biomass			Specific root area		
	d.f.	*SS*	*F*	*P*	*SS*	*F*	*P*
Biotic factor							
Variety		0.73	21.51	<0.0001	$51.88*10^4$	3.75	0.06
Abiotic factors							
Salinity (S)	1	0.58	16.93	<0.0001	$29.30*10^4$	2.12	0.15
Soil moisture (M)	1	2.84	83.46	<0.0001	$24.96*10^4$	1.80	0.18
Soil pH (pH)	1	0.01	0.22	0.64	$10.15*10^5$	7.33	0.0082
S x M	1	0.47	13.84	0.0003	$82.59*10^4$	5.97	0.0166
S x pH	1	0.07	1.97	0.16	$26.35*10^4$	1.90	0.17
M x pH	1	1.17	34.48	<0.0001	$22.11*10^5$	15.98	<0.0001
S x M x pH	1	0.02	0.59	0.45	$17.22*10^5$	12.44	0.0007
Spatial influence							
Distance bole	1	0.02	0.47	0.49	$12.13*10^3$	0.09	0.77
Soil depth	1	0.75	22.03	<0.0001	$15.27*10^5$	11.03	0.0013
Model	10	6.65	19.55	<0.0001	$86.38*10^5$	6.24	<0.0001
Error	107	3.64			$11.76*10^6$		

Results

Fine root bio- (Table 1) and necromass (not shown) of both olive varieties were highly correlated to soil moisture and salinity. 'Barnea' variety possessed a much higher root biomass and bio:necromass ratio (B:N ratio) than 'Proline' variety under moderate salinity (Fig. 2). Specific root areas were found to differ neither between varieties nor under different salinities but increased with increasing pH values and depth (Table 1, Fig. 3). Sap flow density (SFD) declined in both varieties under salt stress (Fig. 4). However, under moderate salinity SFD was lover in 'Proline' than in 'Barnea' variety. Xylem sap osmolality was found to be significantly higher in salt-stressed 'Proline' variety (Fig.5).

Conclusion

Neither in 'Barnea' nor in 'Proline' varieties a reaction of specific root areas to salinity wasfound.

Beneath a higher salt exclusion capacity, the ability of 'Barnea' trees to sustain a high root biomass and a higher sap flow density under salinity and are likely to contribute to the high salt tolerance of this variety by allowing for sufficient water uptake.

Acknowledgment

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