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The response of young pistachio trees grown under saline conditions depends on the rootstock

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Abstract. This study was conducted to assess the effects of saline irrigation water on the behaviour of 7-year-old female trees of Mateur variety grafted onto *Pistacia vera* L. and *Pistacia atlantica* Desf. rootstocks. The three irrigation treatments consisted of: (i) unstressed control trees irrigated with fresh water (ECw: 1.95 dS/m); (ii) moderately saline water (ECw: 5 dS/m); and (iii) saline water with (ECw: 12 dS/m). Individual trunk cross-sectional area and growth of scion shoots were determined on all trees as well as proline and soluble sugar foliar contents. Results showed that tree growth was affected by both salinity and rootstock. Indeed, trees grafted on *P. atlantica* rootstock showed a slight early growth advantage compared with those having *P. vera* as rootstock. For all the treatments, the principal and axillaries shoot length, vegetative bud number and diameter of the trunk cross-sectional areas of stocks were higher on *P. atlantica* rootstock. On both rootstocks, the salinity at 5 dS/m stimulated the length and bud numbers of axillaries shoots and at 12 dS/m, the growth parameters declined significantly. In highly stressed plants budded on *P. vera*, proline and soluble sugars contents were higher than control all over the seasons.

Keywords. *P. vera* – *P. atlantica* – Rootstocks – Salt stress – Growth – Proline – Soluble sugar.

La réponse de jeunes plants de pistachiers sous conditions salines dépend du porte-greffe

Résumé. *Cette étude vise l'étude de l'effet de l'irrigation avec une eau salée sur le comportement de jeunes plants femelles de* Pistacia vera *(cv. Mateur) greffés sur* P. vera *L. et sur* P. atlantica *Desf. Les trois traitements d'irrigation consistent en : (i) des plants non stressés constituant les plants témoins irrigués avec une eau douce (CEw = 1,95 dS/m) ; (ii) des plants irrigués avec une eau relativement salée (CEw = 5 dS/m) ; et (iii) des plants irrigués avec une eau salée (CEw = 12 dS/m). La croissance du tronc et des pousses est déterminée pour tous les plants étudiés. Parallèlement, les contenus foliaires en proline et en sucres solubles sont mesurés. Les résultats montrent que la croissance est affectée aussi bien par la salinité que par les porte-greffes. En effet, les arbres greffés sur* P. atlantica *ont montré une légère supériorité de la croissance comparativement à ceux greffés sur* P. vera*. Pour tous les traitements, la longueur des pousses principales et axillaires, le nombre de bougeons végétatifs et l'aire de la section du tronc des porte-greffes ont été plus élevés chez les plants greffés sur* P. atlantica*. Sur les deux porte-greffes, la salinité de 5 dS/m a stimulé la longueur et le nombre de bourgeons des pousses axillaires. A 12 dS/m, les paramètres de croissance ont chuté de façon significative sur les deux porte-greffes. A la même CE et sur* P. vera*, les contenus foliaires en proline et en sucres solubles ont été plus élevés que les témoins durant toute la saison.*

Mots-clés. P. vera – P. atlantica – *Porte-greffe – Stress salin – Croissance – Proline – Sucres solubles.*

I – Introduction

Salinity is an increasingly serious and costly problem for agriculture. Saline stress can decrease growth, alter photosynthetic rates, and causes morphological change in the leaves (Ghoulam *et al.*, 2002; Munns, 2002). It can limit, particularly, the growth and development of salt-sensitive plants (Greenway and Munns, 1980; McWilliam, 1986). In deed, salinity reduces plant growth due to osmotic and ionic effects on soil solution (Munns and Termaat, 1986; Munns, 2002). In the same way, Salinity affects many aspects of plant metabolism and the accumulation of various organic solutes that contribute to turgor maintenance such as proline and soluble sugars. The main role of proline is probably to protect plant cells against damage of salt by preserving the osmotic balance, stabilizing sub-cellular structures, such as membranes and proteins, and scavenging reactive oxygen species (Ramajulu and Sudhakar, 2000; Munns, 2002; Tester and Davenport, 2003). On other hand, soluble sugars accumulate in cytoplasm balancing water potential through several cellular compartments (Greenway and Munns, 1980; Robinson *et al.*, 1997; Bohnert and Shen, 1999; Bray *et al.*, 2000; Serraj and Sinclair, 2002).

Pistachios (*Pistacia vera* L.) is a xerophytic tree belonging to the Anacardiaceae family which produces edible fruit. It is much more salt tolerant than other nut crops such as almond and walnut. Laboratory studies in Iran and the US (Ferguson *et al.*, 2002) and a nine-year field study in Western Kern County indicate that pistachios can be irrigated with water as salty as 8 dS/m without significant yield reductions (Sanden *et al.*, 2004). However symptoms of toxicity in pistachio and variation of cultivar susceptibility to salinity have been previously described (Behboudian *et al.*, 1986; Picchioni and Miyamota, 1990; Ferguson *et al*., 2002).

This paper describes the effect of irrigation water salinity on growth and compatible solute contents of the Mateur female pistachio variety grafted on the two rootstocks *Pistacia vera* and *Pistacia atlantica*.

II – Materials and methods

1. Plant material and stress treatments

This study was conducted during 2007 in the experimental station of Olive Tree Institute situated at 26 km in the north of Sfax. An orchard of 6-year-old female pistachio trees cv. Mateur grafted on two rootstocks *Pistacia vera* L. (V) and *Pistacia atlantica* Desf. were used. Since May, plants were irrigated three times a month with three water qualities. The irrigation treatments consisted on: (i) unstressed control trees irrigated with fresh water with ECw value of 1.95 dS/m; (ii) moderately saline water with ECw value of 5 dS/m; and (iii) saline water with ECw value of 12 dS/m.

A. Growth measurement

From May, the principal and axillary shoot lengths, vegetative bud number and diameter of the trunk cross-sectional areas of stocks were measured bimonthly.

B. Proline and soluble sugars determination

Proline was determined according to the method described by Bates *et al.* (1973) while soluble sugars were determined following the method described by Robyt and White (1987).

C. Statistics

Statistical analyses were performed using the SPSS-11 Windows logiciel. Significant differences between values of all parameters were determined at $p \leq 0.05$ according to Duncan’s Multiple Range Tests. At least three replicates were made for each field and laboratory measurements.

III – Results and discussion

1. Effects of salinity on growth parameters

For all treatments, the principal and axillary shoot lengths (Fig. 1 A and B), vegetative bud numbers (Fig. 2 A and B) and diameter of the trunk cross-sectional areas of stocks (Fig. 3 A and B) were higher on *P. atlantica* rootstock. So, growth rates varied among rootstocks and changed with time. For example, in July principal and axillaries shoot length of plants irrigated with moderately saline water grafted on *P. atlantica* were respectively 56.99 and 16.66 cm against 37.49 and 12.89 cm on *P. vera* rootstock. On both rootstocks, the salinity at 5 dS/m stimulated the length and bud numbers of axillary shoots while at 12 dS/m, the growth parameters declined significantly.

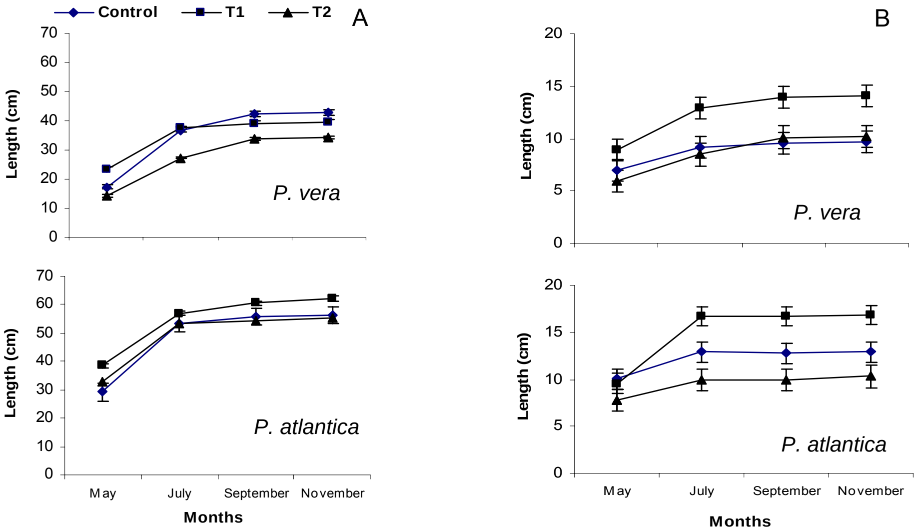

Fig. 1. Apical (A) and axillary shoot (B) lengths of *P. vera* cv. Mateur grafted on *P. vera* and *P. atlantica* rootstocks.

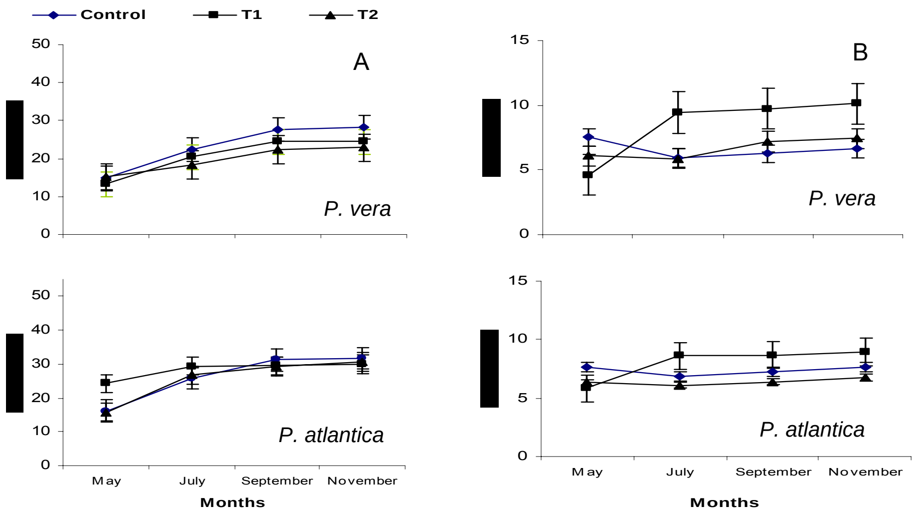

Fig. 2. Stock bud number of apical (A) and axillary shoots (B) of *P. vera* cv. Mateur grafted on *P. vera* and *P. atlantica* rootstocks.

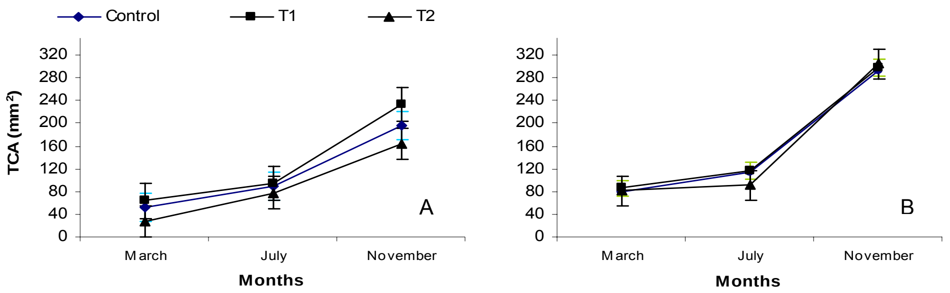

Fig. 3. Trunk cross-sectional areas of *P. vera* cv. Mateur shoot grafted on *P. vera* (A) and *P. atlantica* (B) rootstocks.

The results showed that growth was affected by both salinity and rootstocks. Indeed, trees grafted on *P. atlantica* rootstock showed a slight early growth advantage compared to those having *P. vera* as rootstock. It seems that trees grafted on *P. atlantica* were more stress-tolerant than those grafted on *P. vera.* This may be due to the fact that *P. atlantica* rootstocks have suite morpho-physiological traits allowing them to survive in stress conditions (Grime, 1977; Chapin *et al.*, 1993).

2. Proline and soluble sugars contents

In highly stressed plants budded on *P. vera*, proline and soluble sugar contents were higher (equal or higher than 0.129 mM) than control (equal of lower than 0.118 mM) all over the season except of November values that were comparable for all treatments. Nevertheless, this phenomenon was not observed for soluble sugars on *P. atlantica* rootstock for which the content of this foliar compound was lower than control from June to July and reached the values of control plants in August and exceed them slightly in September (Fig. 4 A and B).

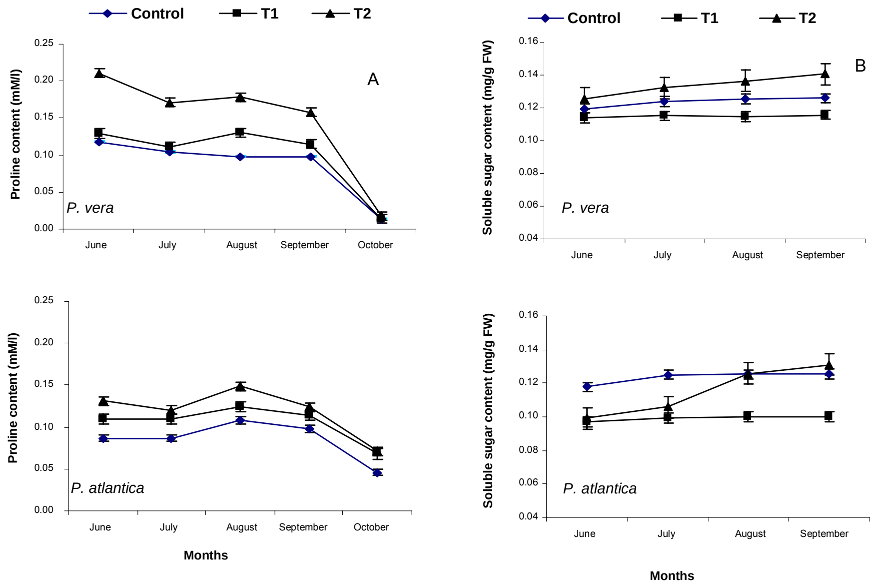

Fig. 4. Foliar proline (A) and soluble sugar (B) contents of *P. vera* cv. Mateur shoot grafted on *P. vera* (A) and *P. atlantica* (B) rootstocks.

The foliar accumulation of proline in *P. vera* rootstock under high salt stress (T_3) seems to protect the cell by balancing the osmotic pressure of cytosol with that of vacuole and external environment. In addition to their role as cytosolic osmotytica, this amino acid may interact with cellular macromolecules such as enzymes and stabilize their structure and function (Rhodes, 1987; Smirnoff and Cumbes, 1989).

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