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Environmental effect on ABA concentration and water potential in olive leaves (*Olea europaea* L. cv "Koroneiki") under non-irrigated field conditions

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Abstract

How does the olive tree respond to environmental stress in the Mediterranean climate under non-irrigated field conditions with respect to leaf abscisic acid (ABA) concentrations and water status? To answer this question we determined simultaneously ABA concentration and water potential (Ψ_1) in olive leaves (*Olea europaea* L. cv "Koroneiki") during three successive years and related them to environmental parameters. The experiment was carried out in the orchard of the Agricultural University of Athens (Greece). The environmental parameters we followed were: (i) soil temperature (soil *T*) at a depth of 20 cm at 08:00 h on the sampling day; (ii) air temperatures, i.e. maximum (Max air *T*) and minimum (Min air *T*) on the previous day; (iii) relative atmospheric humidity at 08:00 h on the sampling day (RH (08:00)) and at 14:00 h on the previous day (RH (14:00)); (iv) weekly rainfall; (v) wind velocity on the previous day and (vi) solar radiation on the previous day. Similar patterns of change of ABA levels and Ψ_1, as well as environmental parameters were observed during both the non-bearing (NBC) and the bearing (BC) growth cycles. Low leaf ABA content was detected during autumn and spring periods. The olive tree tended to acclimatize to prolonged hot-dry periods by reducing the level of ABA at the end of summer, in spite of the low Ψ_1. During winter, leaf ABA content remained low, while Ψ_1 values were at their highest level. Old leaves were found to sustain lower Ψ_1 values than young ones, especially during the hot period. Regression analysis revealed statistically significant correlation between leaf ABA and Ψ_1, as well as between environmental parameters and ABA or Ψ_1 at $P < 0.05$ or at $P < 0.01$ (except for wind velocity). Concerning ABA content, our results revealed young olive leaves (NBC) to be more sensitive to most environmental parameters than old ones (BC). Water status of leaves was affected more strongly by most environmental parameters during the bearing than the non-bearing growth cycle. Temperatures affected Ψ_1 more directly than leaf ABA content.

Keywords: Abscisic acid; Air temperature; Leaf; Leaf water potential; Olive; Rainfall; Relative humidity; Soil temperature; Solar radiation; Wind velocity

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1. Introduction

Environmental parameters are known to affect abscisic acid (ABA) and water status, which in turn affect physiological processes in plants. ABA is related to both, long- and short-term responses of the plant to several environmental stimuli. Environmental parameters, such as dry soil conditions, temperature stress, relative atmospheric humidity, flooding, photoperiod, light intensity, salinity and wounding, as well as internal factors serving as developmental cues, affect ABA concentration in leaves and other plant organs (Zeevaart and Creelman, 1988; Chandler and Robertson, 1994; Benbella and Paulsen, 1998). Water stress of plant tissues results in growth inhibition and in a number of metabolic and physiological changes, including decreased water potential, ABA accumulation, synthesis of new proteins, as well as changes in leaf development and anatomy (Pelah et al., 1997; Cellier et al., 1998; Volaire et al., 1998; Chartzoulakis et al., 1999; Passioura and Munns, 2000; Fitter and Hay, 2002). Low relative atmospheric humidity and extreme values of air temperature increase leaf ABA content by affecting the leaf water status of the plant (Henson, 1984; Carter and Brenner, 1985).

Leaf water potential is also affected by environmental parameters such as relative atmospheric humidity, air and soil temperatures, soil water availability, rainfall, light intensity and wind velocity (Yuanwen and Mingxian, 1991; Gallengo et al., 1994; Shimada et al., 1997; Passioura and Munns, 2000).

In spite of the huge amount of existing information concerning ABA and/or water status relative to drought stress in annual plants, perennial grasses and conifers (Ben Hai Salah and Tardieu, 1997; Darlington et al., 1997; Cellier et al., 1998; Volaire et al., 1998) few papers have been published on perennial shrub- or tree-angiosperms e.g. *Quercus*, willow, peach, apricot (Alvim, 1978; Xiloyannis et al., 1980; Loveys et al., 1987; Gallengo et al., 1994; Abril and Hanano, 1998). To the best of our knowledge seasonal fluctuations of both leaf ABA and Ψ_1 in evergreen angiosperms have not been reported.

Olive, an alternate bearing evergreen tree, is of special interest, since its fruits and leaves have been demonstrated to be important organs for the synthesis of several biological compounds (Rugini and Fedeli, 1990). It is best adapted to the semiarid Mediterranean environment, and is traditionally grown under drought conditions (Gimenez et al., 1997). Olive leaves tolerate extremely low water potential (Rhizopoulou et al., 1991), characterizing them between sclerophyllous desert shrubs and mesophyte conifers (Bongi et al., 1987a, 1987b). Under this climate, the olive tree shows a low growth rate (Giorio and Sorrentino, 1999) attaining the most intense metabolic activity and the highest vegetative growth rate during spring of the non-bearing cycle and to a lower degree during autumn (Drossopoulos and Niavis, 1988a, 1988b). Flower induction takes place in the axillary buds of this new shoot growth in late autumn (Fabbri and Binelli, 2000). Endodormancy is established immediately after floral induction, which is possibly followed by ecodormancy in late winter. Floral bud differentiation is normally initiated in February of the next year and usually leads to very heavy floral load (April–May) and fruiting the following summer-autumn (Rallo et al., 1994).

In spite of the rich literature concerning the physiology and the ecophysiology of olive tree, e.g. photosynthesis and light intensity (Bongi et al., 1987a, 1987b), growth regulators, nutrients and anthesis (Bouranis et al., 1999; Kitsaki et al., 1999; Lavee et al., 1999) and water relations, especially in juvenile trees (Dichio et al., 1997; Gimenez et al., 1997; Chartzoulakis et al., 1999; Giorio and Sorrentino, 1999), there is no information concerning seasonal changes of olive leaf ABA content in adult trees in relation to leaf water status and environmental stress. Thus, in this work, we determined the changes of olive leaf ABA content and Ψ_1 over three years under non-irrigated Mediterranean field conditions in relation to environmental parameters which are known to affect leaf ABA concentration and leaf water status. The effect of environmental parameters on the changes in endogenous ABA and Ψ_1 and the role of this endogenous growth regulator and of Ψ_1 on the physiology and ecophysiology of olive tree are discussed.

2. Materials and methods

2.1. Plant material

Three 40-year-old well-developed olive trees (*Olea europaea* L. cv "Koroneiki"), grafted on seedling stocks and having a height of 6–7 m were selected from