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Agricultural Water Management 78 (2005) 108–121
Agricultural water management
www.elsevier.com/locate/agwat

Salinity and olive: Growth, salt tolerance, photosynthesis and yield

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Accepted 1 April 2005
Available online 14 June 2005

Abstract

Olive (*Olea europaea* L.) is a major tree crop in the Mediterranean region and is moderately salt tolerant. Recent studies suggest that olives can be irrigated with water containing 3200 mg/l of salt (EC_w of 5 dS/m) producing new growth at leaf Na levels of 0.4–0.5% d.w. Salt tolerance in olives appears to be cultivar-dependent and is likely due to control of net salt import to the shoot. The mechanism is located within the roots and prevents salt translocation, rather than salt absorption. It is probably that K–Na exchange at the plasmalemma is involved in regulating the transport of Na^+ to the shoot, while calcium plays a key role in limiting the toxic effects of Na^+ on integrity of the plasma membrane in root cells. In addition, osmotic adjustment, stomatal closure and leaf abscission appear to play a role. Low and moderate salinity is associated with reduction of CO_2 assimilation rate, stomatal and mesophyll conductance. Salinity reduces the fruit weight and oil content while increases the moisture content of fruits. Total phenol content in the olive oil is not affected by moderate NaCl salinity, while the ratio of unsaturated/saturated fatty acids decreases.

Keywords: Salinity; Tolerance mechanisms; *Olea europaea*; Cultivars; Photosynthesis; Yield; Oil quality

1. Introduction

Water scarcity in the Mediterranean basin, especially in countries in arid zone with high rates of population growth, urbanization and industrialization, appears as one of the main factors limiting agricultural development. Within the next 25 years, although irrigated

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doi:10.1016/j.agwat.2005.04.025

areas will increase, large quantities of fresh water supplies will be diverted from agriculture to meet the growing water demand in the municipal and industrial sectors in the region (Hamdi et al., 1995; Correia, 1999). In order to overcome water shortages and to satisfy the increasing water demand for agricultural development, the use of water of low quality (brackish, reclaimed, drainage) is becoming important in many countries.

Recent research developments on salt tolerance of various crops, water, soil and crop management, irrigation and drainage methods will enhance and increase the use of low quality water for irrigation with minimum adverse impacts on yield, soil productivity and environment. The use of saline water is a promising alternative. However, the development of appropriate practices for the use of saline water for irrigation requires an adequate understanding of how salts in the irrigation water affect the soil and plant. Crop type, water quality and soil properties determine to a large extent the management practices required to optimize production. Several examples of successful use of saline water for irrigation can be found in Mediterranean region (Rhoades et al., 1992).

2. Salinity and plant growth

Crops and different cultivars of the same crop vary considerably in their tolerance to salinity (Mass, 1986). Most of the available data on the response of the crops to salinity are based on studies assuming standard steady-state conditions. Mass and Hoffman (1977) concluded that crop yield is not reduced until a threshold of salinity is exceeded, according to the following equation:

$$Y_r = 100 - (EC_e - t)s$$

where Y_r is the relative crop yield (%), 100 is the maximum yield, EC_e is the average salinity of soil saturation extract (dS/m), t is the threshold soil salinity value where yield begins to decline (dS/m), and s is the rate of yield decline per unit increase in EC_e. Beyond the threshold level, yield decreases linearly with increasing salinity. The salinity values at zero yield provide an estimate of maximum salinity that plants can tolerate, and is used to calculate the leaching requirements. Salt tolerance is characterized by the values of both the threshold and slope.

Salt accumulation in root zone causes the development of an osmotic stress (osmotic effect) and disrupts cell ion homeostasis by inducing inhibition in the uptake of essential nutrients like K^+, Ca^{2+} and NO_3^- (possibly leading to nutrient deficiency) and accumulation of Na^+ and Cl^- to potentially toxic levels within cells (specific ion effect) (Marschner, 1995; Zhu, 2001). These primary stresses induce the generation of reactive oxygen species (ROS) (Melloni et al., 2003), cause hormonal changes (Munns, 2002), alter carbohydrates metabolism (Gao et al., 1998), reduce the activity of certain enzymes (Munns, 1993) and impair photosynthesis (Loreto et al., 2003). As a consequence of these metabolic modifications, cell division and elongation declines or it may be completely inhibited and cell death is accelerated (Hasegawa et al., 2000). At a whole-plant level the impacts of salinity are reflected through declines in growth, reduction in yield, and in more acute cases, leaf injuries, which can lead to complete defoliation of plants and their