Scientia Horticulturae 137 (2012) 87–94

Contents lists available at SciVerse ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Comparative effects of exogenous glycine betaine, kaolin clay particles and Ambiol on photosynthesis, leaf sclerophylly indexes and heat load of olive cv. Chondrolia Chalkidikis under drought

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ARTICLE INFO

Article history:
Received 27 July 2011
Received in revised form 10 January 2012
Accepted 11 January 2012

Keywords:
Carbon assimilation rate
Diurnal photosynthesis
Olea europaea
Water stress

ABSTRACT

The aim of the present study was to investigate the effects of exogenous application of kaolin clay particles, glycine betaine and Ambiol on olive (*Olea europaea* L.) plants subjected to drought stress. Two years old self-rooted cv. Chondrolia Chalkidikis olive trees were subjected to two irrigation regimes, i.e. the fully irrigated and the water stressed trees, while they were treated with the three pre-mentioned products. Drought decreased the relative water content, the actual water content and the succulence of leaves significantly, while leaf tissue density was increased. Carbon assimilation rate, stomatal conductance and intrinsic water use efficiency were significantly reduced under drought stress conditions, while intercellular CO_2 increased. Among the alleviating products tested, kaolin clay particles had a significant positive effect on leaf water content, succulence, leaf tissue density and leaf temperature under both drought and well irrigated conditions. Glycine betaine and kaolin clay particles when applied to drought stressed trees, resulted in increased CO_2 assimilation rates compared to control. Furthermore, kaolin clay particles treated leaves exhibited high diurnal CO_2 assimilation rates under drought conditions. Based on the results of the present study, kaolin clay particles and glycine betaine proved to be the most effective, among the applied products, on alleviating the negative effects of drought stress.

1. Introduction

The olive tree (*Olea europaea* L.) is a sclerophyllous species, which is considered to be relatively drought tolerant. Olive plants have adapted various mechanisms in order to respond accordingly and survive under quite severe drought (Diaz-Espejo et al., 2007). Its leaves exhibit several schlerophyllous characteristics in order to be able to maintain sufficient photosynthesis under drought conditions, by increasing the number of mesophyll cells and consequently the number of chloroplasts as well as the CO_2-uptaking cell surface (Bosabalidis and Kofidis, 2002).

Stomata of olive leaves respond strongly to soil water deficit as well as to increasing vapor pressure deficit (VPD) (Moriana et al., 2002; Diaz-Espejo et al., 2007). One of the immediate responses is the reduction of stomatal aperture in order to decrease transpiration rate and maintain positive turgor pressure of the cells (Bosabalidis and Kofidis, 2002; Boughalleb and Hajlaoui, 2010). However, the stomatal closure restricts the CO_2 entry into leaves and as a result, net photosynthesis is reduced due to decreased CO_2 availability at chloroplast level (Centritto et al., 2005). Mesophyll conductance plays also an important role in limiting photosynthesis (Diaz-Espejo et al., 2007). As the stress progresses, the non-stomatal component of photosynthesis is affected and perhaps a light-dependent inactivation of the primary photochemistry associated with photosystem II (PSII) occurs (Angelopoulos et al., 1996). In general, during drought events, the net photosynthesis is reduced while leaf temperature increases, due to reduced cooling effect by the limited transpiration.

Since several environmental factors such as drought, salinity, extreme temperature and high irradiance adversely affect plant growth and development, various products have been exogenously applied in order to reduce the negative effects. One of the most commonly used compounds is glycine betaine, a tertiary ammonium compound, which significantly alleviates the adverse effects of salinity and water stress in many plants (Mäkelä et al., 1998a, 1998b; Ma et al., 2007). Another compound is kaolin clay particles which reduces canopy temperature and therefore reduces heat stress and sunburn damage (Glenn et al., 2003; Rosati et al., 2006) while it is also used as a biological insecticide with good results against olive fruit fly (*Bactrocera oleae* Rossi) and other pests (Pascual et al., 2010). Ambiol, a derivative of 5-hydroxybenzimidazole, is a synthetic antioxidant compound

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doi:10.1016/j.scienta.2012.01.012