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Biochemical responses in leaves of four fig cultivars subjected to water stress and recovery

Mahdiyeh Gholami[a], Majid Rahemi[b,*], Bahman Kholdebarin[c], Somayeh Rastegar[b]

[a] Department of Horticultural Science, Isfahan University of Technology, Isfahan, Iran
[b] Department of Horticultural Science, Shiraz University, Shiraz, Iran
[c] Department of Biology, Shiraz University, Shiraz, Iran

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ABSTRACT

Drought stress is one of the most important factors limiting the growth and productivity of fig (*Ficus carica* L.) in the Iran. Detailed knowledge about the biochemical responses of native figs to drought stress could contribute to the success of vegetation programs. Four cultivars of fig, 'Deyme Ahvaz' (Deym), 'Sabz Estahban' (Sabz), 'Siah' and 'Shahanjir' (Shah), were selected and subjected to drought by withholding irrigation for 14 days. Stressed plants were reirrigated and the recovery was studied for 7 days. Control plants were irrigated daily maintaining soil water content at about field capacity. The levels of pigments and non-enzymatic antioxidants as well as the activities of antioxidant enzymes were quantified. The results demonstrate that the four investigated fig cultivars showed a clear difference in their response to water stress and recovery. Under drought conditions, Deym exhibited higher pigments content and activities of antioxidant enzymes than other cultivars. Catalase had no major antioxidative function in fig. Water stress treatment significantly increased α-tocopherol concentration but decreased ascorbic acid content in the studied cultivars.

1. Introduction

Responses of fruit trees to water deprivation obviously involve a variety of different mechanisms, which may serve to improve plant function in multiple ways. The adaptive responses to water deficit include mechanisms to avoid water loss (osmolyte accumulation), mechanisms for the protection of cellular components (qualitative and quantitative changes of pigments), and damage repair mechanisms (scavengers of toxic oxygen species) (Šircelj et al., 2005).

Active oxygen species (AOSs) are partially reduced forms of molecular oxygen (O_2), resulting from either the excitation of O_2 to form singlet oxygen ($^1O_2$) or the transfer of one, two, or three electrons to O_2 to form, respectively, superoxide (O_2^-), hydrogen peroxide (H_2O_2), or the hydroxyl radical ($^{\bullet}OH$) (Hodges et al., 2004). It has been well-documented that environmental stresses such as temperature extremes (Sung et al., 2003), salinity (Khan and Panda, 2008), waterlogging (Arbona et al., 2008), ozone exposure (Mehlhorn et al., 1990) and drought (Sgherri et al., 2000) induce production of AOS, often leading to oxidative stress.

Oxidative stress occurs when the generation of AOS exceeds the capacity of the plant to maintain cellular redox homeostasis, or, more simply, when the production of AOS exceeds the capacity of the plant to scavenge them (Hodges et al., 2004). These AOSs may initiate destructive oxidative processes such as lipid peroxidation, chlorophyll bleaching, protein oxidation, and damage to nucleic acids (Terzi and Kadioglu, 2006). Plants have evolved specific protective mechanisms, involving antioxidant molecules and enzymes in order to defend themselves against oxidants. In varying degrees, plants possess a number of antioxidants that protect against the potentially cytotoxic species of activated oxygen (Sudhakar et al., 2001). Antioxidants can be divided into three general classes including lipid soluble and membrane-associated α-tocopherol (α-TQ) and β-carotene, water soluble reductants, ascorbic acid (AA) and glutathione (GSH) and enzymes such as superoxide dismutase (SOD), catalase (CAT), guaiacol peroxidase (GPOX) and ascorbate peroxidase (APOX) (Foyer, 1993). Under water stress conditions, levels of these antioxidants have shown increases, decreases, or no effect, depending on the species, duration of drought stress, the antioxidant investigated and the temporal sequence of antioxidant responses (Munné-Bosch and Peñuelas, 2004; Šircelj et al., 2005).

The fig tree (*Ficus carica* L.) was evidently originated in the Middle East (Mars, 2003). Most of the world's fig production occurs in the Mediterranean basin (Sadder and Ateyyeh, 2006). Iran is one

Abbreviations: AA, ascorbic acid; AOS, active oxygen species; APOX, ascorbate peroxidase; α-TQ, α-tocopherol; CAT, catalase; Chl*a*, chlorophyll *a*; Chl*b*, chlorophyll *b*; GPOX, guaiacol peroxidase; GSH, glutathione; H_2O_2, hydrogen peroxide; SOD, superoxide dismutase; WD, drought-stressed plants; WW, control plants.

* Corresponding author. Tel.: +98 711 2287152; fax: +98 711 2286133.
E-mail addresses: gh.mahdiyeh@yahoo.com (M. Gholami), rahemi@shirazu.ac.ir (M. Rahemi), Kholdebarin@shirazu.ac.ir (B. Kholdebarin), srastegar@gmail.com (S. Rastegar).

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