JOP Journal of Ornamental Plants
Available online on: www.jornamental.iaurasht.ac.ir
ISSN (Print): 2251-6433 ISSN (Online): 2251-6441

Stomatal Movement in Response to Root Zone Temperature in Purple Heart (*Tradescantia pallida*)

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Received: 09 February 2016 Accepted: 24 May 2016
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Abstract

The effects of root temperatures (25, 35 and 45°C) and temperature duration (30, 60 and 90 min) on net photosynthesis rate, stomatal conductance and transpiration rate in Tradescantia pallida were investigated. The experiment was conducted under controlled conditions with factorial arrangement based on a completely randomized design (CRD) and four replications. Result showed that, net photosynthesis rate was not significantly different between plants treated with 25 and 35°C. However, aperture area and width increased at 35°C and declined sharply at 45 °C as compared with that at 25 °C. Net photosynthesis rate and stomata1 conductance of plants treated with 45°C decreased to 76 and 68%, respectively, as compared with those at 35°C. Stomatal aperture area of plants treated with 35°C was 27% and 320% higher than those treated with 25 and 45°C, respectively. Stomatal resistance of plants treated with high temperature (45°C) were higher (174%) than those treated with 35°C. In 35 °C, aperture area of plants after 30 min was 61% and 45% higher than those after 60 and 90 min exposure, respectively. The results revealed that, a heat shock of roots at 45°C could lead to a significant decrease in stomatal conductance (by 81%) and transpiration rate (by 60%) as compared with those at 35°C. Overall, the results suggest that the root temperature affects leaf gas exchange and stomatal behavior and has to be taken into account in plant production system, in particular, hydroponics.

Keywords: Heat shock, Photosynthesis, Root zone temperature, Stomatal conductance.

Abbreviations: C_i, Intercellular CO_2 concentration; P_N, Net photosynthetic rate; g_s, Stomatal conductance; r_s, Stomatal resistance.

INTRODUCTION

Tradescantia pallida is an evergreen perennial plant of scrambling stature. It is distinguished by elongated, pointed leaves that have large stomata and used as a model plant for research on stomata behavior. Leaves of plants are equipped with stomata made of pores surrounded by pairs of adjacent guard cells that tightly regulate the pore aperture. Stomata govern leaf diffusive conductance, and thereby influence the photosynthesis and transpiration processes in plants. Plants are exposed to environmental stresses such as temperature and drought in both natural and agricultural environments. Initial responses to stress such as changes in CO_2 fixation, stomatal limitations, and decrease in transpiration occur at the leaf level (Haldimann and Feller 2004; Iriti *et al*., 2009). Stomata play a dominant role in the control of plant water relations and photosynthesis.

To achieve the optimal response to multifactorial environmental changes, stomata perceive many environmental factors i.e. temperature and drought, and have the ability to integrate environmental and endogenous signals (Schroeder *et al*., 2001). Temperature is one of the most important environmental factor limiting growth and survival of plant. High temperature may affect plant metabolism indirectly by promoting evaporative water loss from the soil or directly by injuring the photosynthetic apparatus (Haldimann and Feller, 2004). In warm and moist environments, stomata have been shown to open wide (Feller, 2006), while at low temperatures they tend to close (Wilkinson *et al*., 2001; Veselova *et al*., 2006). Understanding stomatal regulatory strategies is important in determining a plant's overall stress response. When plants are exposed to drying soil, stomatal conductance (gs) and leaf expansion can be regulated by long distance chemical signals travelling from root to shoots (Davies and Zhang, 1991). However, knowledge about the effects of root zone temperature on stomata remains limited. In previous studies attention has been directed to the measurements of stomatal responses to temperature around aerial parts of plants. In this study we focus on gas exchange parameters and stomatal behavior in response to changes in root zone temperature.

MATERIALS AND METHODS

Plant materials and growth conditions

The experiment was carried out in a greenhouse at research field of Faculty of Agriculture, Lorestan University, Khorramabad, Iran (latitude 33o 29/ N and longitude 48o 22/ E and an altitude of 1125 m) during April - July 2015. The greenhouse conditions were 25 ± 2°C / 18 ± 2°C (day night^{-1}), 70 ± 5% RH and light intensity of about 400 µmol m^{-2} s^{-1}. Terminal stem cuttings of *Tradescantia pallida* were obtained from mother plants in the same greenhouse and placed in a sand substrate for rooting. Uniformly rooted cuttings were then transplanted into plastic pots (15 cm diameter and height) filled with a mixture of equal proportions of clay soil, sand and decayed cow manure. Plants were kept well-watered and given a soluble fertilizer once two weeks throughout the cultivation. Physical and chemical properties of soil used in this study were loam texture, pH of 7.45, EC of 2.1 dS m^{-1}, K content of 380 mg kg^{-1}, P content of 18.76 mg kg^{-1}, total N content of 0.15%, and organic carbon content of 1.79%. Young fully expanded leaves were used in the experiments.

Experimental design and salinity treatments

To investigate the response of *Tradescantia pallida* under root zone temperatures treatments, a greenhouse experiment was conducted with factorial arrangement based on a completely randomized design (CRD) with four replications in 2015.

Roots were treated at 25, 35 or 45°C for 30, 60 or 90 min. A water bath was adapted to induce root zone temperature treatment. Then, gas exchange parameters were measured using a portable gas exchange system.

Gas exchange measurements

An LCA4 portable gas exchange system (*ADC Bioscientific, Ltd.,* Hoddesdon, England) was used to measure the rate of net photosynthesis (P_N), transpiration rate (E), stomatal resistance