BIOLOGIA PLANTARUM 41 (4): 613-616, 1998

BRIEF COMMUNICATION

Abscisic acid and ethylene content in *Gerbera jamesonii* plants submitted to drought and rewatering

C. OLIVELLA, M. VENDRELL* and R. SAVÉ

Departament de Tecnologia Horticola, Centre de Cabrils, IRTA,
Carretera de Cabrils s/n, E-08348 Cabrils, Spain
Centre d'Investigació i Desenvolupament, Consell Superior d'Investigacions Científiques,
*J. Girona Salgado 18, E - 08028 Barcelona, Spain**

Abstract

Gerbera jamesonii plants were subjected to a drying and rewatering for 10 d under greenhouse conditions. Transpiration rate and leaf water potential decreased with the application of stress and recovered to a level similar to that observed in the control plants. Leaf abscisic acid concentration increased while ethylene production decreased under stress. After rewatering, each of the parameters recovered, to similar levels, as in the control.

Additional key words: leaf water potential, transpiration rate, water stress.

The participation of hormone balance in the response of plants to drought stress is well documented. The role of the most important one, abscisic acid, is almost elucidated. Considerable controversy surrounds the role of ethylene in the response to drought (El-Beltagy and Hall 1974, Wright 1980, Morgan *et al.* 1990, Narayana *et al.* 1991). Many authors have described an increase in ethylene production as a consequence of a rise in abscisic acid (ABA) concentration in plants submitted to drought. Other authors have found that ABA inhibits ethylene synthesis (Wright 1980). Indoleacetic acid (IAA) could also participate in the regulation of ethylene production. The reasons for such controversy would seem to lie in the methods adopted. A number of studies have been undertaken on excised leaves which suffered a rapid dehydration (Apelbaum and Yang 1981), while elsewhere the whole plant was dehydrated in the soil (Hubick *et al.* 1986).

Received 5 May 1998, *accepted* 15 August 1998.
Fax: (+93) 7533954, e-mail: olivella@cabrils.irta.es

The aim of this paper is to study the ABA-ethylene relationship in *Gerbera jamesonii* plants submitted to water stress and recovery.

Three months old *Gerbera jamesonii* sp. cv. Bolus plants were grown in containers (25 cm in diameter) in a greenhouse with irradiance 115 MJ m^{-2} d^{-1}, temperature 18.1 °C and relative humidity 65 %. A substrate of 4:1 peat:perlite (v/v) with nutrient solution (1:0.6:2) ($N:P_2O_5:K_2O$) was used. The plants were submitted to stress by withholding irrigation. Plants were then divided in five groups: control plants, plants from which water was withheld for 1 d, for 1 d with 3 d of rewatering, for 6 d and for 9 d. Leaf samples were obtained after dawn.

Transpiration rate (E) was determined randomly in ten leaves attached to the plant with a *Licor Li-1600* (Lincoln, USA) porometer (Pearcy *et al.* 1989). The same leaves were detached and then wrapped in wet paper, sealed in aluminium foil and transported to the adjacent laboratory where water potential (Ψ_w) was measured with a *Soilmoisture 3005* (*Soilmoisture Equipment Corp.*, USA) pressure chamber (Turner 1986). To determine ABA concentration, five to ten fully expanded leaves were detached and immediately submerged in liquid N_2, freeze-dried and stored at -80 °C. After purification of leaf extracts with high pressure liquid chromatography, ABA was determined using ELISA (Olivella 1996). To measure ethylene production, two fully expanded leaves were excised and sealed in a 630 cm^3 hermetic containers. Ethylene production was allowed to take place for 9 h. Then, 5 cm^3 were sampled

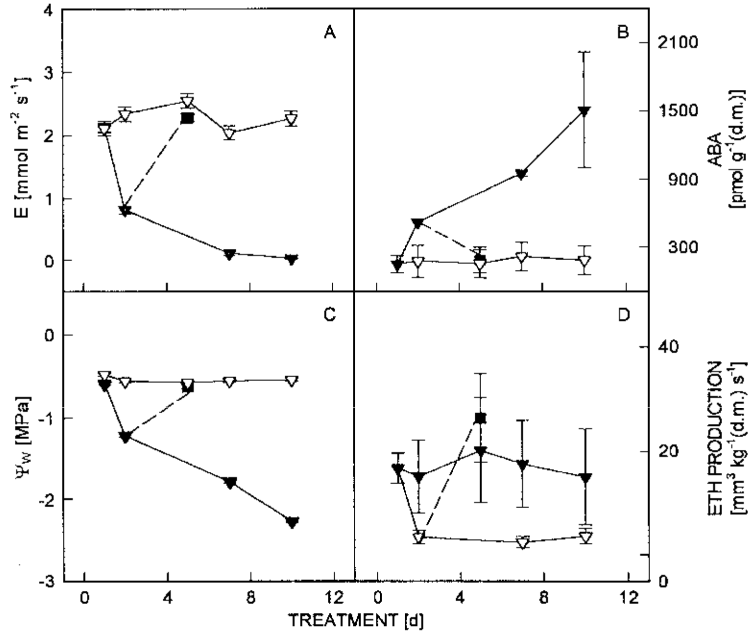

Fig. 1. Variations of transpiration rate, E (*A*), ABA concentrations (*B*), leaf water potential, Ψ_w (*C*), and ethylene (ETH) production (*D*) of *Gerbera jamesonii* plants submitted to water stress and recovery (control - *open triangles*, water stress - *closed triangles*, rehydration - *squares*).

from the air within the containers with a syringe, and injected into a gas-liquid chromatograph (Buesa *et al.* 1994). All the hormone measurements were conducted in triplicate.

Leaf transpiration rate and water potential decreased with the application of stress and recovered to levels similar to those observed in the control plants (Fig.1 *A,C*). The changes observed in ABA leaf concentration (increase during the water stress and decrease during rehydratation; Fig. 1*B*) were similar to results published elsewhere (*e.g.* Reid and Wample 1982, Davies and Zhang, 1991). Leaf ethylene (ETH) production in plants submitted to 1 d of water stress fell significantly after rewatering, ETH production recovered to levels similar to control. In plants submitted to 6 and 9 d of drought, leaf ETH production was lower than in control plants (Fig. 1*D*).

Correlations between E, Ψw, and leaf ABA concentration ($r^2 > 0.8$, $P < 0.05$) were significant and negative. Significant positive correlations between E and leaf ETH production ($r^2 > 0.8$, $P < 0.05$) and a non-significant correlation between Ψ_w and leaf ETH production ($r^2 = 0.65$, $P < 0.1$) were found. A significant negative correlation was found between leaf ABA concentration and ethylene production ($r^2 = -0.62$; $P < 0.05$; Fig. 2). This might indicate that ABA acts as an inhibitor of ethylene synthesis in plants suffering drought (Wright 1980), due to a reduction in aminocyclopropane (ACC)-synthase synthesis (Yang and Hoffman 1984). On the other hand, the decrease in the transpiration rate caused by drought could diminish ACC transport to the leaves, and inhibit ethylene synthesis (Eklund *et al.* 1992). Rewatering might lead to ACC synthesis in roots and its movement to the leaves. Moreover, when ABA leaf concentration fell, an increase in ACC-synthase activity could take place, and might justify the rise in leaf ethylene production. In this study, no increase in ethylene production nor in leaf abscission was observed. Similar findings were reported elsewhere (Tudela and Primo-Millo 1992).

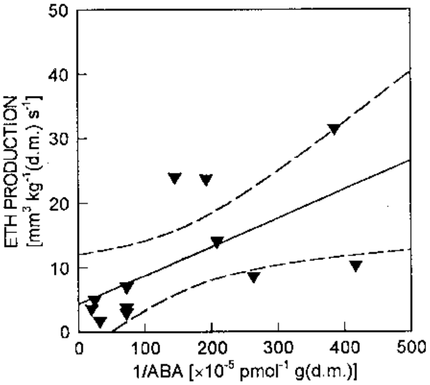

Fig. 2. Correlation between leaf ABA concentrations and ETH productions of *Gerbera jamesonii* plants submitted to water stress. The dotted lines indicate a 95 % level of significance.

References

Apelbaum, A., Yang, S.F.: Biosynthesis of stress ethylene by water deficit. - Plant Physiol. **68**: 594-596, 1981.

Buesa, C., Domínguez, M., Vendrell, M.: Abscisic acid effects on ethylene production and respiration rate in detached apple fruits at different stages of development. - Rev. Español Cien. Tecnol. Aliment. **34**: 495-506, 1994.

Davies, W.J., Zhang, J.: Root signals and the regulation of growth and development of plants in drying soil. - Annu. Rev. Plant Physiol. Plant mol. Biol. **42**: 55-76, 1991.

Eklund, L., Cienciala, E., Hällgren, J.E.: No relation between drought stress and ethylene production in Norway spruce. - Physiol. Plant. **86**: 297-300, 1992.

El-Beltagy, A.S., Hall, M.A.: Effect of water stress upon endogenous ethylene levels in *Vicia faba*. - New Phytol. **73**: 47-60, 1974.

Hubick, K.T., Taylor, J.S., Reid, D.M.: The effect of drought on levels of abscisic acid, cytokinins, gibberelins and ethylene in aeroponically-grown sunflower plants. - Plant Growth Regul. **4**: 139-151, 1986.

Morgan, P.W., He, C.-J., De Greef, J.A., De Proft, M.P.: Does water deficit stress promote ethylene synthesis by intact plants? - Plant Physiol. **94**: 1616-1624, 1990.

Narayana, I., Laloue, S., Saini, H.: Water stress-induced ethylene production in wheat. A fact or artefact ? - Plant Physiol. **96**: 406-410, 1991.

Olivella, C.: Aspectes analítics i estudi del balanç hormonal de les plantes de gerbera sotmeses a estressos abiòtics. - Tesi Doctoral. Universitat de Barcelona, Barcelona 1996.

Pearcy, R.W., Ehleringer, J.R., Mooney, H.A., Rundel, P.W.: Plant Physiological Ecology. Field Methods and Instrumentation. - Chapman and Hall, London 1989.

Reid, D.M., Wample, R.L.: Water relations and plant hormones. - In: Pharis, A., Reid, D.M. (ed.).: Hormonal Regulation of Development. III. Role of Environmental Factors. Pp. 513-578. Springer-Verlag, Berlin 1982.

Tudela, D., Primo-Millo, E.: 1-Aminocyclopropane-1-carboxylic acid transported from root to shoots promotes leaf abscision in Cleopatra mandarin (*Citrus reshni* Hort. ex Tan.) seedlings rehydrated after water stress. - Plant Physiol. **100**: 131-137, 1992.

Turner, N.C.: Adaptation to water deficits: a changing perspective. - Aust. J. Plant Physiol. **13**: 175-190, 1986.

Wright, S.T.C.: The effect of plant growth regulator treatements on the levels of ethylene emanating from excised turgid and wilted wheat leaves. - Planta **148**: 381-388, 1980.

Yang, S.F., Hoffman, N.E.: Ethylene biosynthesis and its regulation in higher plants. - Annu. Rev. Plant Physiol. **35**: 155-189, 1984.