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Short Communication

Effect of Salinity on Some Gas Exchange Characteristics of Grape (*Vitis vinifera*) Cultivars

ELNAZ HATAMI, MAHMOOD ESNA-ASHARI[1] AND TAIMOUR JAVADI†
Department of Horticultural Sciences, Faculty of Agriculture, Bu-Ali Sina University, Hamedan, Iran
†*Department of Horticulture, Faculty of Agriculture, Kordistan university, Iran*
[1]Corresponding author's e-mail: m.esnaashari@basu.ac.ir

ABSTRACT

Two grape cultivars, Rish-Baba and Sahebi were subjected to different levels of salinity and some physiological characteristic including the rate of photosynthesis, stomatal conductivity, under-stomatal carbon dioxide and transpiration determined under 0 (control), 25, 50, 75, 100, 125 and 150 mM NaCl levels. One-year old rooted cuttings were cultivated in pots containing perlite and fed with Hoagland nutrient solution. By increasing salinity stress, the rate of photosynthesis, stomatal conductivity and transpiration was decreased. The rate of sub-stomatal carbon dioxide decreased at the beginning of salt stress but increased later, which was primarily related to decreasing stomatal conductivity and later increase was associated with lack of consuming CO_2 in photosynthesis process. Based on these results, Rish-Baba cultivar was more tolerant to salinity stress. © 2010 Friends Science Publishers

Key Words: Grape; Salinity; Stomatal conductivity; Sub-stomatal CO_2; Transpiration

INTRODUCTION

Salinity is one of the most severe abiotic factors that limits plant growth and impairs agricultural productivity (Misra *et al.*, 1997; Blumwald *et al*., 2000; Paranychianakis & Chartzoulakis, 2005; Neocleous & Vasilakakis, 2007). Grapevines are often grown in regions under stress conditions and are vulnerable to climate change (Dos Santos *et al*., 2007).

If excessive amounts of salt enter the plant, it will evenly rise to the toxic level that reduces photosynthetic leaf area to a level that can not sustain the plant growth (Misra *et al.*, 1997; Munns, 2002; Paranychianakis & Chartzoulakis, 2005; Neocleous & Vasilakakis, 2007). Transpiration rate of plants decreases under osmotic stress through different mechanisms such as stomatal conductivity reduction. This mechanism of transpiration reduction is an adaptive process that conserves water for the later stages of plant growth (Misra *et al.*, 2002; Tardieu, 2005). Stomatal closure is a prime factor reducing photosynthesis rate in response to osmotic stress (Misra *et al.*, 2002; Munns, 2002).

Lawlor and Cornic (2002) stated that, stomatal conductivity decreases with decreasing relative water content (RWC) and finally the actual amount of CO_2 assimilation decreases leading to photosynthesis reduction. Reduced stomatal conductivity in grape leaves has been associated with a high salinity level and vice versa (Ben-Asher *et al*., 2006). Fisarakis *et al*. (2001) reported that, photosynthesis rate in grapevine cv. "Sultana" leaves was significantly reduced under salinity stress. They stated that salt-induced changes in photosynthesis were associated with reducing stomatal conductivity. Salinity also reduced leaf transpiration. Chartzoulakis *et al*. (2002) reported that increasing Na^+ and/or Cl^- concentration in olive leaves has a tendency to the CO_2 assimilation rate reduction.

In this study, two grape (*Vitis vinifera* L.) cultivars; Rish-Baba and Sahebi were subjected to different levels of salinity and some physiological characteristics including the rate of photosynthesis, stomatal conductivity, under-stomatal carbon dioxide and transpiration determined and finally the relation between these parameters and salinity tolerance in the cultivars was evaluated.

MATERIALS AND METHODS

Plant materials: Two grape (*Vitis vinifera* L.) cultivars (Rish-Baba & Sahebi) were supplied from one year old rooted cuttings, transferred into plastic pots containing perlite in March and kept in greenhouse condition for accelerating their growth. Roots of cuttings were washed with deionized water and their branches cut back to one shoot before transplanting. Plants were irrigated daily with half-strength Hoagland nutrient solution for 45 days before salinization began. Salt treatments were imposed when the shoots were 15-20 cm in length and the experiment was lasted 20 days.

Salinity treatments: The experiment was worked at the Faculty of Agriculture of Bu-Ali Sina University

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greenhouse during 2007-2008. Salinity was imposed by adding 0 (control), 25, 50, 75, 100, 125 and 150 mM L^{-1} NaCl to half-strength Hoagland nutrient solution (Hoagland & Arnon, 1950) with the increments of 25 mM per day to avoid salt shock. Electrical conductivity (EC) of solution was 1.6, 3.4, 5.1, 6.7, 8.1, 10.1 and 11.4 dS m^{-1}, respectively. Plants were irrigated every single day with 350 mL Hoagland solution for 30 sec. The solution of each tank was brought to its initial volume by addition of deionized water, while a fresh solution was supplied every 10 days, in order to avoid change in solution concentration greater than 5% (Chartzoulakis *et al*., 2002). This project was conducted in a factorial experiment based on a completely randomized block design with four replications.

Gas exchange measurements. Leaf photosynthesis (Pn), stomatal conductivity (gs), under stomatal carbon dioxide (Ci) and transpiration (T) were measured by portable gas analyzer system [IRGA (LCA-4)]. All measurements were carried out in the morning (09.00-11.00) at photosynthetic photon flux density of 1200-1400 μ mol m^{-2} s^{-1} every three days (Ben-Asher *et al*., 2006). For the measurement of the above parameters, one plant from any experimental unit was selected and two fully-expanded leaves on the young shoot were sampled.

Data analysis. The data were subjected to analysis of variance (ANOVA) using SAS software and the means were compared by Duncan multiple range test at $p<0.05$.

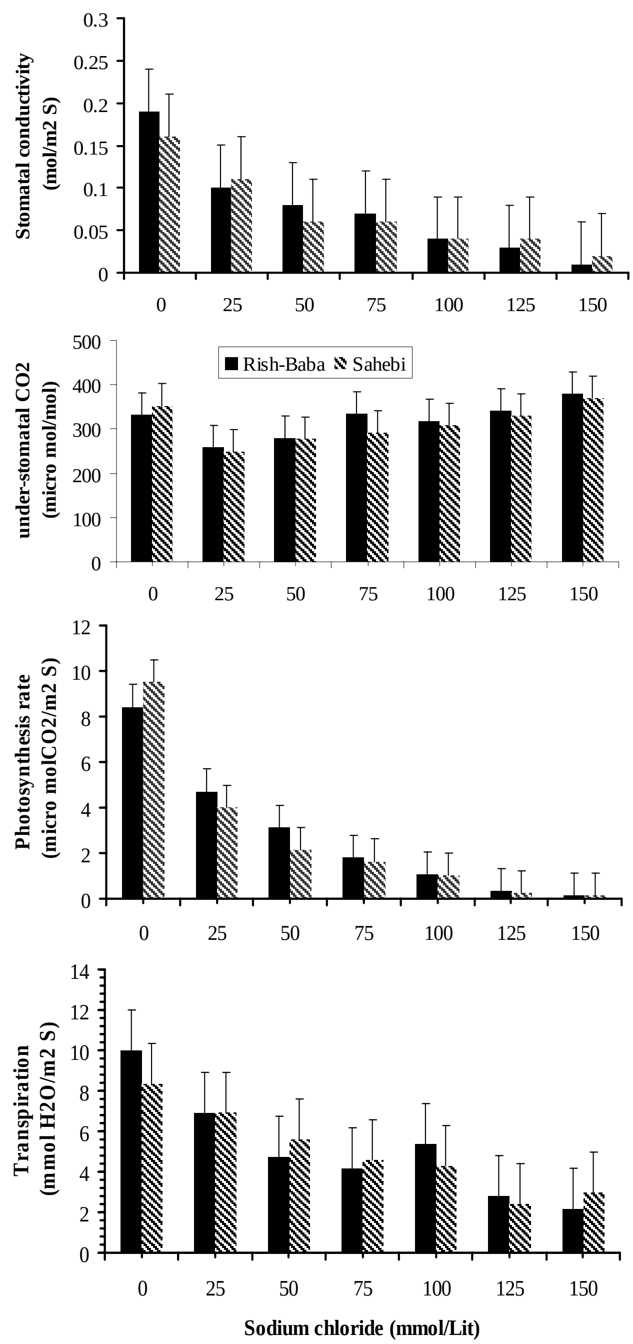
RESULTS

Salt stress had significant effect on gas exchange parameters, but no significant difference was observed between the cultivars in this relation. Interaction of cultivar and salinity stress could only affect on photosynthesis significantly at $p<0.05$. Comparing the means showed that stomatal conductivity and the rate of transpiration and photosynthesis were decreased by increasing salinity levels, while under-stomatal carbon dioxide concentration was decreased at the beginning of salinity application and then increased later (Fig. 1).

DISCUSSION

The reason why under-stomatal carbon dioxide was primarily decreased in both cultivars is because leaf stomatal conductivity decreases with increasing salinity stress to prevent water loss, but this in turn also prevents carbon dioxide to diffuse into the stomata (Fig. 1). Later increase in under-stomatal carbon dioxide is due to the lack of carbon dioxide consuming and assimilation by leaf mesophyll cells (Ahmadi & Baiker, 2000). Therefore leaf stomatal conductivity is the main factor limiting photosynthesis process at the beginning stages of salt stress. However, at the later stages when salinity becomes more severe, leaves are not capable of consuming carbon dioxide.

Fig. 1: Effect of salinity on stomatal conductivity, under-stomatal CO_2, rate of photosynthesis and transpiration grapevine leaf. The vertical bars represent Standard Deviation, the asteric marks above each histogram represents significance at $p<0.05$ over the control values



Non-stomatal factors such as leaf chlorophyll content limit photosynthesis rate. According to the reports, with stomatal conductivity less than 0.05 mol m^{-2} s^{-1}, non-stomatal factors are more effective in reducing photosynthesis (Flexas *et al*., 2004).

In the case of transpiration reduction, stomatal closure is more effective than carbon dioxide uptake (Taiz & Zeiger, 2006). In this study, stomatal closure in Rish-Baba caused more transpiration reduction resulting in this cultivar was more tolerant to salinity stress (Fig. 1). In both cultivars the transpiration rate decreased with decreasing stomatal closure, but this trend was slightly different with Rish-Baba, so that transpiration rate suddenly increased in 100 mM NaCl treatment, then decreased at higher levels of salt stress (Fig. 1). Such physiological behavior in this cultivar was not clearly understood and needs further studies especially at the molecular level. Olive trees gradually close their stomata to prevent water loss by transpiration. Moreover, under severe conditions, stomatal closure seems to be the earliest response to prevent cell dehydration and damaging plant survival (Chedlia *et al*., 2007). The main reason for decreasing photosynthesis rate under osmotic stress condition has also been reported by many workers as stomatal closure (Misra *et al.,* 2002; Munns, 2002; Neocleous & Vasilakakis, 2007). In fact closing stomata in response to salinity stress is a regulative mechanism to decrease water loss from plant tissues, but this phenomenon, on the other hand, decreases photosynthesis rate and finally increases sensitivity to stress (Misra *et al.*, 2002; Paranychianakis & Chartzoulakis, 2005; Tardieu, 2005). If stomatal closure and reduction in transpiration last long, carbon dioxide assimilation by leaf tissues decreases followed by reduction in photosynthesis and plant growth (Misra *et al.*, 2002; Tardieu, 2005). Results of the present study showed that, in both cultivars stomatal closure and decreasing water loss followed by photosynthesis reduction were occurred under salt stress condition (Fig. 1) and plants therefore could not use avoidance mechanism but tolerance to salinity.

Some studies have shown that, leaf conductance in grapevine was more sensitive to salinity than transpiration and photosynthesis is therefore better factor to evaluate severity of salinity and its negative effects on photosynthesis rate (Ben-Asher *et al*., 2006). Higher level of stomatal closure in Rish-Baba showed that this cultivar resists more under salinity stress and losses lower water compared with Sahebi, while the later cultivar with more opening stomata losses more water. Based on the results of this experiment, Rish-Baba was ranked as more tolerant g to salinity stress.

REFERENCES

Ahmadi, A. and D.A. Baiker, 2000. Stomatal and non-stomatal photosynthesis limited factors in wheat under drought stress condition. *Iranian J. Agric. Sci.,* 31: 813–825

Behboudian, M.H., E. Torokfalvy and R.R. Walker, 1986. Effects of salinity on ionic content, water relations and gas exchange parameters in some citrus scion-rootstoch combinations. *Sci. Hort*., 28: 105–126

Ben-Asher, J., I. Tsuyuki, B.A. Bravdo and M. Sagih, 2006. Irrigation of grapevines with saline water, I. leaf area index, stomatal conductance, transpiration and photosynthesis. *Agric. Water Manag*., 83: 13–21

Blumwald, E., G.S. Aharon and M.P. Apse, 2000. Sodium transport in plant cells. *Biochim. Biophys. Acta*., 1465: 140–151

Chartzoulakis, K., M. Loupassaki, M. Bertaki and I. Androulakis, 2002. Effect of NaCl salinity on growth, ion content and Co_2 assimilation rate of six olive cultivars. *Sci. Hort*., 96: 235–247

Chedlia, B.A., B.R. Bechi and M. Boukhris, 2007. Effect of water deficit on olive trees cv. Chemlali under field conditions in arid region in Tunisia. *Sci. Hort*., 113: 267–277

Cramer, G.R., A. Ergul, J. Grimplet, R.L. Tillett, E.A.R. Tattersall, M.C. Bohlman, D. Vincent, J. Sonderegger, J. Evans, C. Osborne, D. Quilici, K.A. Schlauch, D.A. Schooly and J.C. Cushman, 2007. Water and salinity stress in grapevines: early and late changes in transcript and metabolite profiles. *Funct. Integr. Genomic*s, 7: 111–134

Dos Santos, T.P., M. Lopes, M.L. Rodrigues, C.R. De Souza, J.M. Ricardo-da-Silva, J.P. Maroco, J.S. Pereira and M.M. Chaves, 2007. Effect of deficit irrigation strategies on cluster microclimate for improving fruit composition of Moscatel field-grown grapevines. *Sci. Hort*., 112: 321–330

Fisarakis, I., K. Chartzoulakis and D. Stavrakas, 2001. Response of Sultana vines (*V. vinifera* L.) on six rootstocks to NaCl salinity exposure and recovery. *Agric. Water Manag*., 51: 13–27

Flexas, J., C. Josep, M.E. Jose, G. Jeroni, G. Javier, L. El-Kaderi, F.M. Sara, T.M. Maria, R. Miquel, R. Diego, S. Bartolome and M. Hipolito, 2004. Understanding down-ragulation of photosynthesis under water stress: future prospects and searching for physiological tools for irrigation management. *Annl. Appl. Biol*., 144: 273–283

Hoagland, D.R. and D.S. Arnon, 1950. The water culture method for growing plants without soil. *Calif. Agric. Exp. Stat. Cic.,* 374: 1–32

Lawlor, D.W. and G. Cornic, 2002. Photosynthetic carbon assimilation and associated metabolism in relation to water deficit in higher plants. *Plant Cell Environ*., 25: 255–294

Misra, A.N., S. Sahu, M. Misra, P. Mohapatra, I. Meera and N. Das, 1997. Sodium chloride induced changes in leaf growth, and pigment and protein contents in two rice cultivars. *Biol. Plant,* 39: 257–262

Misra, A.N., A.K. Biswal and M. Misra, 2002. Physiological, biochemical and molecular aspects of water stress responses in plants and the biotechnological applications. *Proc. Nat. Acad. Sci. (India)*, 72 B: 115–134

Munns, R., 2002. Comparative physiology of salt and water stress. *Plant Cell Environ*., 25: 239–250

Neocleous, D. and M. Vasilakakis, 2007. Effect of NaCl stress on red raspberry (*Rubus idoeus* L. Autumn Bliss). *Sci. Hort*., 112: 282–289

Paranychianakis, N.V. and K.S. Chartzoulakis, 2005. Irrigation of Mediterranean crops whit saline water: from physiology to management practices. *Agric. Ecosyst. Environ*., 106: 171–187

Taiz, L. and E. Zeiger, 2006. *Plant Physiology*, 4th edition. Sinaur Associates Inc., Sunderlan, Massachusetts

Tardieu, F., 2005. Plant tolerance to water deficit: physical limits and possibilities for progress*. Geo. Sci.*, 337: 57–67

Walker, R.R., E. Torokfalvy, N.S. Scott and P.E. Kriedemann, 1981. An analysis of photosynthetic response to salt treatment in *Vitis vinifera*. *Australian J. Plant Physiol*., 8: 359–374

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