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Response of Tomato Plant towards Amino Acid Under Salt Stress in a Greenhouse System

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ABSTRACT

Salinity is one of the most progressive environmental factors limiting the productivity of crop plants. To evaluate the effects of foliar application of amino acid on fruit yield, some elements and proline of tomato under salinity stress, a greenhouse experiment were conducted in a factorial arrangement based completely randomized design with three replicates. Five salinity levels of irrigation water including 2, 4, 6, 8 and 10 dS m^{-1} and 3 levels of amino acid (0, 2 and 4 g L^{-1}) by foliar application method was used. Although, the results indicated that salinity of irrigation water significantly reduced fruit yield (kg per plant) of tomato, amino acid had no significantly effect on fruit yield. The highest fruit yield were obtained at the without amino acid and 2 dS m^{-1} of salinity level. Also, statistical testing shows significant increase in proline concentration in plant leaves with application of water salinity at 8 and 10 dS m^{-1}. The highest (713.9 mg kg^{-1}) proline concentration was obtained at the 2 g L^{-1} amino acid and 10 dS m^{-1} of salinity level. Although, the concentration of K and Mg in plant leaves was significantly decreased by salinity, the concentration of Na in plant leaves was continuously increased with increasing salinity levels. However, results showed that salinity and amino acid had no significant effect on concentration of calcium in leaf. The highest (3.03%) nitrogen concentration in plant leaves were obtained at the without amino acid and 10 dS m^{-1} of salinity level.

Key words: Amino acid, salinity, yield, foliar application, ninhydrin

INTRODUCTION

Salinity is one of the most important environmental factors responsible for substantial losses in agricultural production in many parts of the world (Khoshbakht *et al*., 2014). It is estimated that over 800 million ha of land in the world are affected by both salinity and alkalinity (Munns, 2005). The osmotic stress let to the accumulation of toxic levels of Na and Cl ions and the uptake prevention of essential nutrients (K, Ca and NO_3) (Munns, 2002). Salinity led to the reduction of water uptake capability of roots and consequently inhibition of plant growth and a reduction in the crop productivity (Netondo *et al*., 2004). Soil salinity inhabits plant growth, with considerable reductions in plant biomass (Rameeh *et al*., 2004). Plants are exposed to abiotic and biotic stresses. Salt stress is a common a biotic stress factor seriously affecting plant production and limiting their. Salt stress led to reduces the photosynthetic leaf area of the plant (Erdal *et al*., 2013). Plants growing under saline stress face three main problems including: (1) High salt concentrations in the soil solution that led to high osmotic pressure and low soil water potential,

(2) High concentrations of toxic ions such as Na and Cl and (3) Nutrient imbalance as a result of depressed uptake, damaged internal distribution and shoot transport of nutrient minerals (Hu and Schmidhalter, 2005).

Amino acids are molecules containing a carboxylic acid group, an amine group and a side chain that varies between amino acids (Baumann, 1984). Amino acid has a chelating impact on micronutrients, which make the absorption and transportation of these nutrients inside the plant easier due to its impact on cell membrane permeability (Marschner, 1995). Amino acids may be play an main role in metabolism and protein assimilation of plant which necessary for plant cells and consequently increase fresh and dry weight of plant (Abo Sedera *et al*., 2010). Previous works have demonstrated that amino acids can influence the physiological activities in plant growth and their yield (Mohamed, 2006). The effects of amino acids on the growth and productivity of vegetables have been studied by many researchers. For instance, Akladious and Abbas (2013) indicated that high water salinity levels reduced growth properties and chemical constituents of tomato plants but amino acids increased plant growth parameters. El-Din and Abd El-Wahed (2005) found that application of amino acids substantially increased plant height, number of flower heads and fresh and dry weights of aerial part of chamomile plant.

Although many studies have focused on the effects of amino acid on plant growth, analogous data are limited for application of Iran conditions where supplementary irrigation is necessary for an adequate productivity of the crop. The aim of this study was to study the effects of foliar application of amino acid and salinity on some properties of tomato plant.

MATERIALS AND METHODS

Experimental design: A greenhouse experiment was conducted to explore salt stress and amino acid effects on some properties of tomato in 2014. Tomato seeds (Honey) were sown in a box of coco-peat substrate and young plants at four leaf stages were transferred in 7 L pots filled with coco peat+perlite (V/V = 50). One tomato plant was cultivated per pot. Johnson nutrition solution was used for fertigation of the plants. The treatments were defined by a two-factorial design of five irrigation water salinity levels (2, 4, 6, 8, 10 dS m^{-1}) and three amino acid levels (0, 2, 4 g L^{-1}). The 15 treatment combinations were replicated three times and arranged in a randomized complete design. Amino acid (Botamisol as free L-amino acids) at three levels was sprayed with a hand sprayer. Some plant properties including fruit yield (kg per plant), some elements and concentration of proline in plant leaves were determined at the end of growth period.

Extraction of P, K, Na, Ca and Mg: For extractions of P, K, Na, Ca, Mg, leaf plant samples were ground by mill and then ashed in a furnace at 550°C under a gradual increase in temperature for 2 h (Caballero *et al*., 2009). Thus samples were added 10 mL of 2 M HCl for digestion and then they were filtered and diluted by distilled water. The concentration of total nitrogen was determined by Kjeldhal method (Bremner and Mulvaney, 1982). Phosphate concentration was determined by colorimetrically and the concentration of K was measured by flame photometry methods (Gholamhoseini *et al*., 2013). Calcium and magnesium determined by the EDTA complexometric titration method. The concentration of proline was measured by ninhydrin method according to Dong *et al*. (2005).

Statistical analyses: Statistical analyses were conducted with software package SAS 9.1 for Windows. Two-way ANOVA was used to assess the effects of amino acid and salts stress on some properties of tomato. Comparison of absolute values for these parameters was conducted with Duncan's multiple range test at $p<0.05$.

RESULTS AND DISCUSSION

Fruit yield: The results indicated that fruit yield (kg per plant) affected by salinity. Increasing irrigation water salinity levels resulted in a signi cant reduction in fruit yield. However, the application of amino acid had no significant effect on fruit yield. The highest fruit yield were obtained at the without amino acid and 2 dS m^{-1} of salinity level (Fig. 1). Increasing irrigation water salinity levels resulted in a signi cant reduction in fruit yield of tomato. These results agree with those obtained by Zadeh and Naeini (2007) on canola, Magan *et al*. (2008) on tomato, El-Lethy *et al*. (2013) on wheat, Dawood *et al*. (2014) on common bean and Sadak *et al*. (2015) on faba bean plant. Al-Busaidi *et al*. (2009) reported that under saline stress plant parameters of different tomato cultivars were reduced compared to the control. The reduction of tomato yield under saline conditions may be due to the harmful impact of salt stress on plant growth, the disturbance in mineral uptake and/or enhancement of plant respiration. Although, in present study amino acid had no significant effect on fruit yield, according to Abdul Qados (2010) study on mung bean plants, the application of amino acids had the most effect on dry weight of plants. Also, Hammad and Ali (2014) reported that foliar spraying of amino acids increased all growth parameters of wheat plant compared to untreated plants. Sadak *et al*. (2015) observed that the application of amino acid as foliar spray greatly improved yield either in plants irrigated with tap water or irrigated with different salinity water. However, according to other studies, increase in plant yield due to application of amino acids may be due to providing a readily source of growing substances which form constitutes of protein in the living tissues (Sadak *et al*., 2015). Abdul Qados (2010) revealed that, spraying mung bean plants with amino acid could alleviate the harmful effect of water salinity on plant height and plant dry weight. Nassar *et al*. (2003) found that the application of polyamine to plant have been shown to promote cell division and consequently led to promotion of general growth. Also, amino acid can help to stabilize membrane and wall properties (Velikova *et al*., 2000) and protect plant against environmental stress (Mo and Pua, 2002).

Total nitrogen: Data in Fig. 2 showed total nitrogen of tomato leaf affected by salinity irrigation and spraying plants with amino acid. Total nitrogen increased under high salinity level (10 dS m^{-1}) as compared to control. With the exception of salinity level 2 and 10 dS m^{-1}, application of amino acid caused increase in total nitrogen of plant leaf as compared to control (Fig. 2). The highest

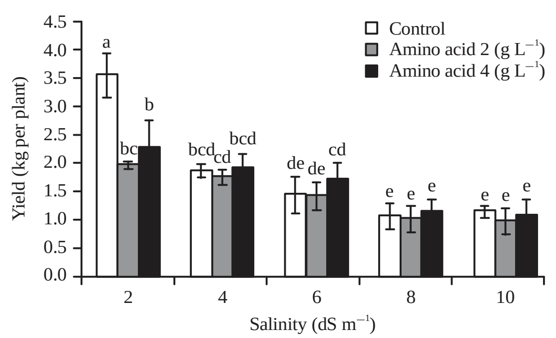

Fig. 1: Effects of foliar application of amino acid and salinity of irrigation water on fruit yield of tomato. Mean values followed by different letters indicate significance difference among treatments at p<0.05 by Duncan test. Bars indicate standard deviations

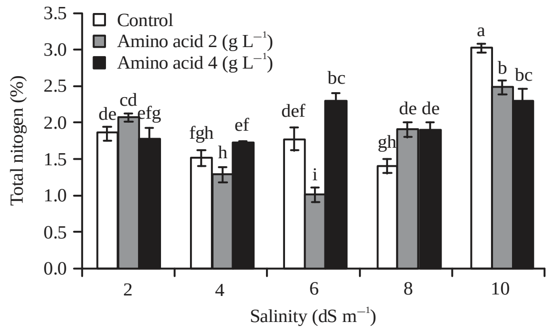

Fig. 2: Effects of foliar application of amino acid and salinity of irrigation water on total N in tomato leaf. Mean values followed by different letters indicate significance difference among treatments at p<0.05 by Duncan test. Bars indicate standard deviations

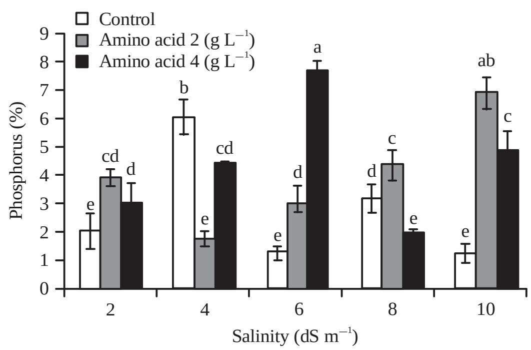

Fig. 3: Effects of foliar application of amino acid and salinity of irrigation water on concentration of P in tomato leaf. Mean values followed by different letters indicate significance difference among treatments at p<0.05 by Duncan test. Bars indicate standard deviations

nitrogen concentrations were obtained at the without amino acid and 10 dS m^{-1} of salinity level (Fig. 2). However, Pessarakli (1991) stated that salinity can reduce N accumulation in plants.

Phosphorus (P) concentration: With the exception of salinity level 4 dS m^{-1}, P concentration in tomato leaf was significantly increased in plant sprayed with amino acid compared with control plants (Fig. 3). However, positive influences of amino acids on concentration of plant elements under salt stress conditions were reported by Sadak *et al*. (2015). Sadak *et al*. (2015) reported that spraying plants with amino acids under salt stress conditions dramatically increased the concentrations of N, P, K, Mg and Ca in the leaf tissues of faba bean than control. Abdul Qados (2010) indicated that, exogenous application of arginine (an amino acid) under salinity level caused increase in all parameters of yield components as compared to the corresponding salinity level.

Potassium (K) concentration: Increasing irrigation water salinity levels resulted in a signi cant reduction of K concentration of tomato leaf and these reductions reached the highest values at 10 dS m^{-1} salinity levels compared with control plants. Exogenous application of amino acids under 4, 6, 8 and 10 dS m^{-1} salinity levels caused increases in K concentration (Fig. 4). Moreover,

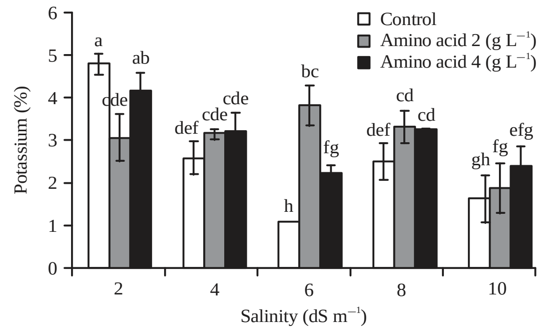

Fig. 4: Effects of foliar application of amino acid and salinity of irrigation water on concentration of K in tomato leaf. Mean values followed by different letters indicate significance difference among treatments at $p<0.05$ by Duncan test. Bars indicate standard deviations

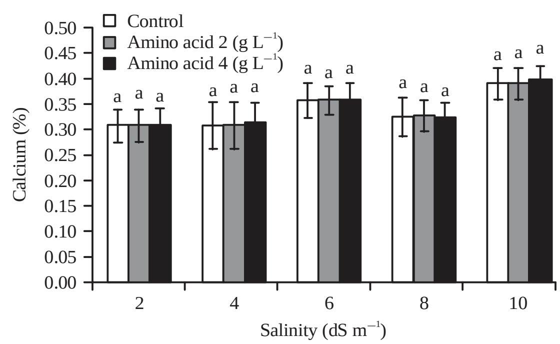

Fig. 5: The effects of foliar application of amino acid and salinity of irrigation water on concentration of Ca in tomato leaf. Mean values followed by different letters indicate significance difference among treatments at $p<0.05$ by Duncan test. Bars indicate standard deviations

Taffouo *et al*. (2009) reported that, the significant decrease of cowpea yield observed under salt stress would be partly related to a significant reduction of foliar chlorophyll contents and K concentration under salt stress. The inhibition effects of water salinity on yield of tomato plants may be due to salinity which prevents the growth through reduced water absorption, reduction of metabolic activities due to toxicity of Na and Cl and nutrient deficiency caused by ionic interference (Ghoulam *et al*., 2002; De Lacerda *et al*., 2003).

Calcium (Ca) and Mg concentration: The results in Fig. 5 showed that salinity and amino acid had no significant effect on concentration of calcium in leaf tomato. Results showed that increasing water salinity levels resulted in a significant reduction in to Mg concentration of tomato leaf. The concentration of Mg in 2 dS m^{-1} of salinity level was significantly higher than that other salinity levels (Fig. 6). In present study the effect of amino acid on concentration of plant elements was not detected. Although, the concentration of K and Mg was significantly decreased by salinity, the concentration of Na was continuously increased with increasing salinity levels. However, results showed that salinity and amino acid had no significant effect on concentration of calcium in leaf. Asik *et al*. (2009) concluded that salinity has an antagonistic impact on the uptake of Ca and Mg

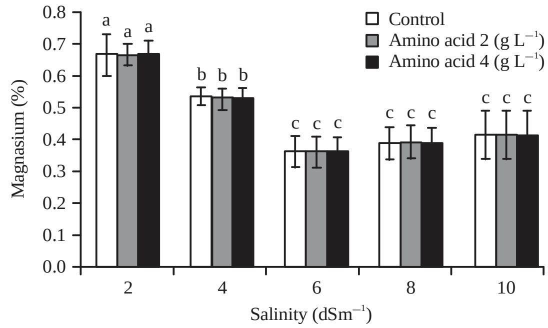

Fig. 6: Effects of foliar application of amino acid and salinity of irrigation water on concentration of Mg in tomato leaf. Mean values followed by different letters indicate significance difference among treatments at $p<0.05$ by Duncan test. Bars indicate standard deviations

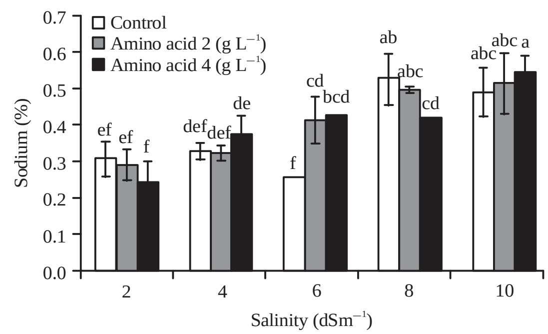

Fig. 7: Effects of foliar application of amino acid and salinity of irrigation water on concentration of Na in tomato leaf. Mean values followed by different letters indicate significance difference among treatments at $p<0.05$ by Duncan test. Bars indicate standard deviations

which was caused by displacing Ca in membrane of plant root cells. Also, Sadak *et al.* (2015) illustrated that the reduction in Ca and Mg uptake under salt stress conditions may be due to the suppressive impact of Na and K on Ca and Mg or due to the reduced transport of Ca and Mg cations.

Sodium concentration: As shown in Fig. 7, irrigation of tomato plant with saline water increased Na concentration compared with those irrigated with tap water (2 dS m^{-1} of salinity). According to results of Sadak *et al.* (2015), although, Na concentration was higher in plants grown under different salinity levels, but the application of amino acid signi cant reduced Na concentration in faba bean leaves.

Proline concentration: The results in Fig. 8 indicated that proline concentration of tomato leaf increased gradually with increasing salinity levels as compared with tap water (2 dS m^{-1} of salinity). Application of amino acid mixture as foliar spray with 4 g L^{-1} concentration signi cant decreased proline concentration in 10 dS m^{-1} salinity level. The highest proline concentration was obtained at 2 g L^{-1} amino acid and 10 dS m^{-1} of salinity level (Fig. 8). The results indicated that the concentration proline in tomato leaf was significantly increased with high salinity levels (8 and 10 dS m^{-1}). Abdul Qados (2010) reported that the concentration of proline in mung bean

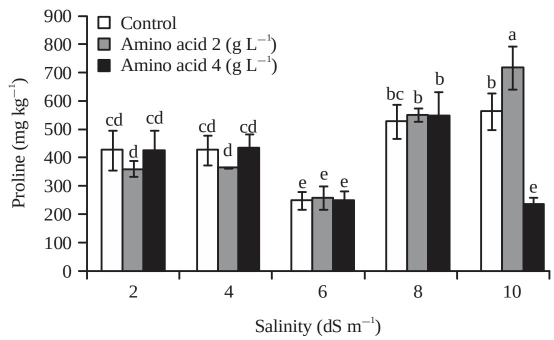

Fig. 8: Effects of foliar application of amino acid and salinity of irrigation water on concentration of proline in tomato leaf. Mean values followed by different letters indicate significance difference among treatments at $p<0.05$ by Duncan test. Bars indicate standard deviations

seeds increased with increasing salinity levels as compared with those plants grown on non-saline water. The result of proline in tomato leaf is in good agreement with those obtained by Mohamedin *et al*. (2006) on sunflower. Although in this study amino acid had no significant effect on concentration proline, Abd El-Samad *et al*. (2010) showed that amino acids treatment significantly decreased proline accumulation in the shoots and roots of plants.

CONCLUSION

In the present study, the performance and suitability of amino acid under water salinity for the soilless culture of tomato plants were studied in a greenhouse. Results showed that fruit yield decreased due to salt stress as compared to the non-stressed plants. The results also indicated that the concentration of K and Mg in plant leaves was significantly decreased by salinity. However, the concentration of proline and Na in plant leaves was remarkably increased with increasing salinity levels. The highest proline concentration was obtained at the 2 g L^{-1} amino acid and 10 dS m^{-1} of salinity level. Nonetheless, the effect of amino acid on fruit yield was not statistic significant.

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