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Growth of Tomato as Affected by Foliar Application of Salicylic Acid and Salinity

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Abstract: Using salicylic acid (SA) is a relatively inexpensive and quick method for promoting growth and yield of crops under saline conditions. Tomato (*Lycopersicon eculentum*) is an important cash crop, grown in most parts of Iran, including salt affected areas. Consequently a pot experiment was conducted to evaluate the effect of SA on tomato growth under salt stress condition. The experiment was complete randomized block with 3 replications, 4 levels of irrigation water salinity (0, 4, 8 and 12 dS/m) and 4 levels of SA concentration (0, 10^{-6}, 10^{-4} and 10^{-2} M) which was foliar sprayed. There was highly significant reduction in shoot fresh and dry weights and number of flowers per plant with increasing salinity. There was no significant difference between shoot fresh and dry weighs and number of flowers per plant for SA treated plants and control. However, fresh weight of plants treated with 10^{-6} M SA was significantly higher than the other two concentrations. Within each salinity level, SA application did not have significant effects on the measured characteristics. Based on these results, under this experimental condition, SA acid did not improve the salt tolerance of tomato. However, lower concentrations of SA needs to be evaluated.

Key words: Salicylic acid · Salinity · Tomato · Salt tolerance · Plant growth hormone

INTRODUCTION

Salinity is one of the main factors that adversely affect crop production in arid regions, which can result in more than 50% yield reduction of major crops. It reduces plant growth, alters ionic relations by ionic and osmotic effects and induces oxidative stress [1, 2]. Plant growth hormones, such as salicylic acid (SA) can be used to promote growth and yield of plants under various stress conditions including salt stress.

Salicylic acid is a naturally occurring plant hormone of phenolic nature that has diverse effects on tolerance to abiotic stresses [2, 3]. Application of SA induced tolerance in plants to many biotic and abiotic stresses including fungi, bacteria and viruses, chilling, drought, heat [4]. It participates in regulation of physiological process in plants such as stomatal closure, ion uptake and transport, inhibition of ethylene biosynthesis, transpiration, stress tolerance, membrane permeability and photosynthesis and growth [3, 5]. The effects of SA on physiological processes of plants depend on its concentration, type of plant, the stage of plant growth and environmental conditions; thus, it can have beneficial or inhibitory effects on plant physiological processes.

Seed priming of wheat with SA significantly improved seedling establishment, dry weight of root and top part and chlorophyll a and b contents of wheat under saline conditions [6]. Application of SA also significantly increased dry weights of root and top part of barley [7], soybeans [8] and maize [9] under saline conditions. Seed priming significantly increased wheat germination under both saline and non-saline conditions [10]. They also reported that, SA increased cell division in both root and stem; hence, increasing plant growth. Salt tolerance of wheat was also improved by application of SA through rooting medium.

The positive effects of SA on tomato plants has also been reported under salinity stress [11, 12]. Salt tolerance of two faba bean genotypes was also reported to increase by SA application [13]. Low concentration of SA significantly improved mungbean growth under salinity stress due to decreased concentrations of Na^+, Cl^- and

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H_2O_2 in plants, decreased electrolyte leakage, increased N, P, K and Ca contents and increased antioxidant enzyme activity [2]. In contrast, studies with maize [14] and *Arabidopsis* [15] showed inhibitory effects of SA. Application of high concentration of SA (10 mM) either proved inhibitory or was no additional benefit to salt stressed mungbean [2].

Tomato (*Lycopersicon eculentum*) is an important cash crop in many parts of the world, including arid region of Darab, Iran. Due to contrasting reports on the effect of SA, importance of tomato as cash crop and lack of studies on this region, this research was undertaken to evaluate the effects of foliar applied SA in alleviation of salinity stress on tomato.

MATERIALS AND METHODS

This factorial pot experiment was conducted in open air at the campus of Islamic Azad University, Darab branch, Iran. The experimental design was complete randomized block with three replications. The first factorial was four levels of irrigation water salinity (0, 4, 8 and 12 dS/m) and the second factorial was SA concentration (0, 1×10^{-6}, 1×10^{-4} and 1×10^{-2} M). 48 plastic pots (30×30 cm) were filled with 2 cm of gravel and 5 kg of a loamy sand soil (pH = 7.8 and EC_e=0.47 dS/m). The pots were carefully filled with the soil to achieve a uniform bulk density (1.4±0.5 g/cm^3). Each pot received 400 kg/ha of urea (in two applications of 200 kg/ha), 150 kg/ha of triple superphosphate and 100 kg/ha of potassium sulfate.

Two seedlings of tomato (cv. Viva) were planted in each pot and were irrigated with tap water (0.326 dS/m). The seedlings were at two leaf stage at the time of planting. After two weeks of irrigation with tap water, each pot was thinned to one tomato plant. Except control, the rest of the pots were irrigated daily with 2 dS/m saline water three weeks after seedling plantation to prevent salt shock. Thereafter, every 3 days the rest of irrigation water salinities were imposed. To prevent salt build up, the pots were irrigated with 1.5 liter of designated irrigation waters to achieve a 30% leaching fraction.

Six weeks after seedling plantation, 30 ml of SA solution (pH=6.5) with appropriate concentrations were foliar applied to each tomato plant with a hand sprayer in early morning. The top of the pots were covered with plastic sheet to prevent contamination of soil with SA solution. Control plants were also sprayed with 30 ml of distilled water adjusted to pH 6.5. Three months after plantation, tomato plants were cut from top of the pots. Number of flowers per plant and the shoot fresh and dry weights were measured.

All data were subjected to Analysis of Variance (ANOVA) using MSTATC statistical software. Also, means were separated by Duncan's Multiple Range Test (DMRT) at 0.05 probability level.

RESULTS AND DISCUSSION

The results of analysis of variance test showed that the effects of irrigation with saline water on fresh and dry shoot weights and number of flowers per plant were highly significant (Tables 1 and 2). There was no significant difference between fresh and dry shoot weights of 8 and 12 dS/m irrigation water salinities.

SA did not significantly affect the growth characteristics evaluated in this experiment (Tables 1 and 2). Although fresh shoot weight at 1×10^{-6} M concentration did not significantly different than control, it was significantly higher than the other two higher concentrations of SA (Table 2). The results of many other studies with SA under saline condition has shown that lower concentrations of SA is often more effective than higher concentrations [2, 4].

There were not significant interactive effects of saline water and SA concentration on tomato plant growth characteristic measured (Table 1). The Duncan's multiple range test results indicated at each saline water there was no significant effects of SA application on fresh and dry shoot weights, as well as number of flowers per plant (data not shown). Participatory role of SA on flowering has been reported [16].

Table 1: Analysis of variance *F* values for the measured growth characteristics of tomato.

Treatment	Fresh shoot weight	Dry shoot weight	No. flowers per plant
	---------------g/plant---------------		
Saline water (EC_i)	32.154 **	13.025 **	12.539 **
Salicylic acid Concentration	0.843 ^{NS}	0.352 ^{NS}	0.215 ^{NS}
EC_i×Salicylic Acid	0.706 ^{NS}	0.678 ^{NS}	1.296 ^{NS}

NS and **: not significant and highly significant at 0.01 probability level, respectively.

Table 2: Means comparison for tomato growth characteristics between different irrigation with saline water and salicylic acid concentrations using DMRT at 5%

Treatment	Fresh shoot weight	Dry shoot weight	Number of flowers per plant
	---g/plant---		
Saline water (dS/m)			
0	47.0 a	13.6 a	9.8 a
4	37.1 b	11.6 b	4.7 b
8	27.9 c	9.9 c	2.2 c
12	21.1 d	9.4 c	0.4 d
Salicylic acid concentration (M)			
0	33.5 ab	11.0 a	3.8 a
1×10^{-6}	35.7 a	11.5 a	4.8 a
1×10^{-4}	31.7 b	10.8 a	3.8 a
1×10^{-2}	32.1 b	11.2 a	4.7 a

Means in the same column with different letters differ significantly at 0.05 probability lev

The results indicate that SA concentrations used in this experiment and perhaps the environmental conditions at the experimental site did not have the expected positive effects on tomato plant (cv. Viva). At higher concentrations, it is possible that SA by negatively affecting plant physiological processes, thus, decreasing fresh and dry shoot weights and number of flowers per plant. This phenomenon has been observed in other experiments. Application of high SA concentration (10^{-3} M) negatively affected growth, photosynthesis and yield of mungbean under salinity stress [2]. In that experiment, high SA concentration showed inhibitory effects even at non-saline condition. Under both saline and non-saline conditions N, P, K and Ca concentrations were reduced, antioxidant enzyme activities declined and thus, photosynthesis and growth were retarded [2]. The same has been reported for maize [14] and wheat [17].

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REFERENCES

1. Daneshmand, F., M.J. Arvin and K. Manouchehri, 2009. Effect of acetylsalicylic acid (aspirin) on salt and osmotic stress tolerance in *Solanum bulbacastanum* in vitro: Enzymatic antioxidants. American-Eurasian J. Agricultural and Environmental Sci., 6(1): 92-99.
2. Khan, N.A., S. Syeed, A. Masood, R. Nazar and N. Iqbal, 2010. Application of salicylic acid increases contents of nutrients and antioxidative metabolism in mungbean and alleviates adverse effects of salinity stress. International J. Plant Biol., 1: e1.
3. Ashraf, M., N.A. Akram, R.N. Arteca and M.R. Foolad, 2010. The physiological, biochemical and molecular roles of brassinosteroids and salicylic acid in plant processes and salt tolerance. Critical Reviews in Plant Sci., 29(3): 162-190.
4. Najafian, S., M. Khoshkui, V. Tavallali and M.J. Saharkhiz, 2009. Effect of salicylic acid and salinity in thyme (Thymus vulgaris L.): investigation on changes of gas exchange, water relations and membrane stabilization and biomass accumulation. Australian J. Basic and Applied Sci., 3: 2620-2626.
5. Abdel El-Wahed, M.S.A., A.A. Amin and E.M. Rashad, 2006. Physiological effect of some bioregulators on vegetative growth, yield and chemical constituents of yellow maize plants. World J. Agricultural Sci., 2(2): 149-155.
6. Kaydan, D., M. Yagmur and N. Okut, 2007. Effects of salicylic acid on the growth and some physiological characters in salt stressed wheat (*Triticum aestivum* L.). Tarim Bilimleri Dergisi, 13(2): 114-119.
7. El-Tayeb, M.A., 2005. Response of barley grains to the interactive effect of salinity and salicylic acid. Plant Growth Regulation, 45: 215-224.
8. Gutierrez-Coronado, M.A., C. Trejo-Lopez and A. Largue-Saavedra, 1998. Effects of salicylic acid on growth of roots and shoots in soybean. Plant Physio. Biochem., 36: 653-665.

9. Khodary, S.E.A., 2004. Effect of salicylic acid on the growth, photosynthesis and carbohydrate metabolism in salt-Gstressed maize plants. Int. J. Agric. Biol., 6: 5-8
10. Dolatabadian, A., S.A.M. Modarres and M. Sharifi, 2009. Effect of salicylic acid and salt on wheat seed germination. Acta Agriculturae Scandinavica, Section B-Plant Soil Sci., 59: 456-464.
11. Stevens, J., T. Senarantna and K. Sivasithamparam, 2006. Salicylic acid induces salinity tolerance in tomato (*Lycopersicon esculentum* cv. Roma): associated changes in gas exchange, water relations and membrane stabilization. Plant Growth Regul., 49: 77-83.
12. He, Y. and Z.J. Zhu, 2008. Exogenous salicylic acid alleviates NaCl toxicity and increases antioxidative enzyme activity in *Lycopersicon esculentum*. Biol. Plant, 52: 792-795.
13. Azooz, M.M., 2009. Salt stress mitigation by seed priming with salicylic acid in two faba bean genotypes differing in salt tolerance. Int. J. Agric. Biol., 11: 343-350.
14. Nemeth, M., T. Janda, E. Horvath, G. Szalai, 2002. Exogenous salicylic acid increases polyamine content but may decrease drought tolerance in maize. Plant Sci., 162: 569-574.
15. Borsani O., V. Valpuesta and M.A. Botella, 2001. Evidence for a role of salicylic acid in the oxidative damage generated by NaCl and osmotic stress in Arabidopsis seedlings. Plant Physiol., 126: 1024-1034.
16. Cleland, C.F. and A. Ajami, 1974. Identification of the flower-inducing factor isolated from aphid honeydew ad being salicylic acid. Plant Physiol., 54: 904-906.
17. Amin, A.A., E. Rashad, M. Fatma, 2008. Changes in morphological, physiological and reproductive characters of wheat plants as affected by foliar application with salicylic acid and ascorbic acid. Australian J. Basic and Applied Sci., 2: 252-261.