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Effect of salicylic acid on yield and yield component of grapevine (Vitis vinifera) under salinity stress condition

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ABSTRACT: Abstract
Salinity is one of the limiting factors in agricultural production. Salicylic acid, as a plant growth regulator, is able to increase the salt tolerance of crops. Therefore, the effects of salicylic acid on quantitative and qualitative traits and some physiological parameters of grapevine (Cul. Ruby) under saline conditions was studied in Khash, Iran. The treatments include foliar application of four concentrations of salicylic acid (0, 0.1, 0.5 and 1 mM) in a randomized complete block design with three replications. Results showed that the effect of salicylic acid on yield, bunch number, bunch width, bunch weight, berry length and berry number per bunch were significant. But there were no significant effects recorded for bunch length. The effect of salicylic acid on the growth and yield were significant. Based on the results of this research, using 1 mM salicylic acid to increase the yield of Ruby grapevine under salt stress conditions is recommended.

***Keywords*:** grapevines, salinity, yield, Salicylic acid, bunch number

INTRODUCTION

Grapevines (Vitis vinifera) from the genus Vitis rank first among fruit crops in the world in terms of both production and economic importance (Vivier and Pretorius, 2002). Grapevines is one of the most cultivated crop of Iran because of its relative resistance to drought conditions and adverse environmental conditions (Amiri and Fallahi, 2007). Salinity is one of the most important abiotic stresses that reduces growth and yield of crops through osmotic stress and toxic ions (Fozouni et al, 2015). Grapevines varieties are ranked moderately sensitive to salinity stress by most researchers (Shani et al. 1993; Walker et al. 2002). However, one study ranked V. vinifera varieties as sensitive (Prior et al. 1992). Grapevine show decreasing rates of photosynthesis with increasing salinity (Cramer et al., 2007). The photosynthetic decrease is primarily related to reduced stomatal aperture and increased resistance to CO_2 diffusion. At lamina concentrations higher than about 150 mM Cl^- in the tissue water, irreversible damage may occur. Leaves containing up to 150 mM Cl generally retain the capacity to recover normal physiological function once the salt stress is removed (Walker et al. 1981).

Salicylic acid (SA) has long been known as a signal molecule in the induction of defense mechanisms in plants. The application of 0.05 mM SA also improved plant growth after salt stress and caused the accumulation of ABA and prolines (Shakirova et al, 2003). SA added to the soil also had an ameliorating effect on the survival of maize plants during salt stress and decreased the Na^+ and Cl^- accumulation (Gunes et al, 2007). Lipid peroxidation and membrane permeability, which were increased by salt stress, were lower in SA treated plants. Root drenching with 0.1 mM SA protected tomato (Lycopersicon esculentum) plants against 200 mM NaCl stress (Stevens et al., 2006). It increased the growth and photosynthetic rate of the plants, as well as the transpiration rate and stomatal conductance, and reduced electrolyte leakage by 32%. Wang et al., (2001), reported that the levels of ABA and JA were generally found to increase, although, interestingly enough, SA declined in response to salinity. when SA was applied by soaking the grains before sowing, it improved the drought tolerance of plants. Soaking wheat grains with 100 ppm acetyl-SA had an alleviating effect on the injury of plants subjected to drought stress (Al-Hakimi and Hamada, 2001). Spraying wheat leaves with 1 mM SA increased antioxidant enzyme activities, chlorophyll and relative water content, and the membrane stability index, and decreased H2O2 and lipid peroxide levels under moderate water stress (Agarwal et al., 2005).

materials and methods

In the 2012-2013 growing season an experiment was conducted in agricultural lands located at Khash, Iran. Experiment was conducted in a randomized complete block design with three replications. The treatments include foliar application of four concentrations of salicylic acid (0, 0.1, 0.5 and 1 mM). The soil was sandy loam with a pH and electrical conductivity of 5.8 dS and 8.7, respectively. In winter of 2012 by sampling the soil of area gardend and testing of soil salinity, a saline vineyard was selected. Then 36 vines of grapevine (Cul. Ruby) were selected in the selected vineyard in order to applying treatments. In April 2013, foliar applications were applied when the grapevine stems grow to 15 to 20 cm. Measured traits including fruit yield, the number of bunch, bunch weight, bunch length, bunch width, berry length and the berry number. The data analysis of variance was performed using SAS software and mean were compared with Duncan test at 5% level.

Results and discussion

Analysis of variance showed that effects of salicylic acid treatments on the mean berry length and berry number were significant at 1% and fruit yield, number of bunch, bunch weight and the bunch width was significant at the 5% level but the effect of salicylic acid treatment on the bunch length was not significant (Table 1).

Table 1. Analysis of effect of salicylic acid on some grapevines traits under salinity stress.

Source of variation	df	Mean square						
		Fruit yield	**Bunch numbers**	**bunch weight**	**bunch length**	**bunch width**	**berry length**	**berry number**
replicate	2	0.163ns	4.33ns	248.2ns	0.31 ns	0.07 ns	0.206 ns	467 ns
treatment	3	2.51*	81.22*	1615.7*	1.14 ns	2.22*	2.52**	5468**
errore	6	0.528	13.8	558.0	1.89	0.50	0/32	369
C.V		29.8	23.05	16.4	10.5	8.1	5.6	7.9

***, ** and ns, significant difference in levels of 5% and 1%, and no significant difference, respectively.**

The comparison of the mean (Table 2) showed that treatment with 1 mM salicylic acid with 3.7 tons of grapevines produced per hectare, had the highest yield of fruit, followed by 0.5 mM salicylic acid with production of 2.6 ton ha-1 (table 2). But, there were no significant differences between control vine and those treated by 0.1 mM SA in terms of fruit yield. The effect of salicylic acid treatments on the number of bunch was significant at 5% level (Table 1). three-fold increase of fruit yield of 1 mM salicylic acid treated vines compared to the control was considerable, and the effect of this treatment could be related to improvement of physiological processes associated with yield. The above results showed the positive effects of salicylic acid on reducing the negative effects of salinity. The effect of salicylic acid treatments on the number of bunch was significant at 5% level (Table 1). The number of bunch was significantly increased only in vines treated with 1 mM SA.

Table 2. mean comparison of effect of salicylic acid on some grapevines traits under salinity stress

treatments	Yield and yield component						
	Fruit yield (kg)	**Bunch numbers**	**bunch weight (g)**	**Bunch length (cm)**	**Bunch width (cm)**	**berry length (mm)**	**berry number**
0.0 SA	1600^{b}	11.67^{b}	138.3^{ab}	10.30^{a}	8.70^{ab}	9.36^{b}	218b
0.1 SA	1900^{b}	15.00^{b}	120.7^{b}	11.20^{a}	7.73^{b}	11.20^{a}	198b
0.5 SA	2560^{ab}	14.33^{b}	175.3^{a}	11.10^{a}	8.63^{ab}	9.30^{b}	289a
1.0 SA	3667^{a}	23.67^{b}	153.7^{ab}	11.80^{a}	9.83^{a}	10.47^{ab}	271a

***, ** and ns, significant difference in levels of 5% and 1%, and no significant difference, respectively.**

Bunch weight was statistically affected by salicylic acid treatments at 5% level. Mean comparison showed that the highest bunch weight (average 175 g) were recorded in vines that treated with 0.5 mM salicylic acid, and there were no significant differences between control and 1 mM salicylic acid. But the lowest bunch weight (121 g) was produced in vines those treated with concentration of 0.1 mM.

Analysis of variance showed that salicylic acid treatments had no significant effects on bunch length (Table 1). As a result, a significant difference between concentrations were not observed in terms of bunch length (Table 2). Bunch width was statistically affected by salicylic acid treatments at 5% level. The highest (9.8 cm) and lowest (7.7 cm) bunch width were recorded in vines that treated with 1.0 and 0.1 mM salicylic acid, respectively (Table 2).
Comparing the mean showed that salicylic acid treatments lead to longer ruby grapevine berries and a concentration of 0.1 mM salicylic acid had the greatest influence and longest berries (11.2 mm) was observed in this concentration. Vines that treated by concentration of 0.5 mM salicylic acid and control vine had the lowest berry length (Table 2). Mean comparison of treatments showed that the average berry number per bunch was influenced by salicylic acid treatments and the highest berry number per bunch was observed in 0.5 (289) and 1.0 mM (271). There was no significant difference between vine treated by 0.1 mM SA and those untreated (Table 2).
Increase of resistance to stress conditions under salicylic acid application seems related to accumulation of abscisic acid in root, which is cause an adaptation to stress. Also sugars increases under salicylic acid treatment that lead to increase of osmotic gradient and induced the vine resistance against water loss, increase water content of leaves and improved growth under stress conditions (Tasgin et al., 2003). It seems that salicylic acid used in this research was led to increase of grapevine salinity tolerance. Salinity affects the absorption of minerals by the roots and transportation of them to shoot. Tari et al (2002) observed that salicylic acid application could increase survive of tomato plant under salt stress, and prevent from accumulation of sodium and chlorine ions. Probably salicylic acid had the same effect in grapevines. According to the results of this study, application of 1 mM salicylic acid, which is relatively cheap and available, as the best treatment to improve yield of ruby grapevine varieties in saline conditions is recommended. It seems that during the formation of flower buds, salicylic acid and gibberellic acid by increasing the proportion of total RNA to phosphates, and a number of unknown proteins in plant tissues accelerated the flowering, and in fact there was a synergic effect between gibberellic acid and salicylic acid in the formation of flower buds (Raskin et al., 1992).

Conclusions

salicylic acid treatments had a significant effect on qualitative and quantitative traits with the exception of bunch weight. In this experiment, Ruby cultivar of grapevines treated with salicylic acid showed 3.2 times higher yield compared to control. This yield increase is very significant and will cause the higher production per unit area, and thereby thus more revenue will accrue to the vine owners. The yield increase is primarily resulting from increase in the number of bunch per vine was treated with salicylic acid. In addition to the number of bunch per vine, the higher bunch width, berry number, berry length and larger fruit had produced under salicylic acid treatment.

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