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Salicylic acid application alleviates adverse effects of high salinity on growth of olive (Picual cv.) seedlings

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As continuous efforts to maximize efficiency of utilization of soil and water resources, one–year old olive (Picual cv.) seedlings were subjected (during two growth seasons 2016-2017) to test that how far salicylic acid (SA) can mitigate salinity adverse effects on olive seedlings. In this sense, obtained results showed that salinity reduced most vegetative parameters and nutrient content. However, SA application can mitigate these adverse effects of salinity. Under salinity condition, treating olive seedlings with SA (Spring 400 ppm + soil 200 ppm) led to increase in plant height. Leaf number and shoot number were increased when SA applied at 200ppm in soil, leaf dry weight increased under salinity when SA applied at (400ppm) in soil. In respect of nutrient status, under salinity condition , N content increased when SA applied at 200 ppm in soil , meanwhile , leaf K content increased with applying SA at (Spring 200 ppm + soil 400 ppm) under salinity condition. The pronounced ameliorative impact of SA under saline condition may be referred to effect of SA on alleviating the imposed salt stress, either via osmotic adjustment or by conferring desiccation or salinity resistance to plant cells.

Keywords: olive seedlings, salinity, foliar application, Salicylic acid, antioxidant, growth parameters, mineral leaf content.

INTRODUCTION

Studies concerning olive growth rate, fruit and oil production as a influenced by salinity had been conducted and emphasized that, despite of the olive's general tolerance for abiotic stress, including that caused by salinity (Melgar et al., 2012), environmental conditions causing increased root zone salinity can lead to reduced photosynthetic activity, vegetative growth, and fruit and oil production and therefore, salinity is expected to harm production in commercial olive orchards.

Farzaneh et al., (2017) indicated that salt stress had an inhibitory effect on the vegetative growth of olive plants. Injury rating value of plants was found to increase significantly as the salt concentration was raised. For instance stem height increment decreased significantly with raising salinity. Shoot fresh and dry weights were decreased as a result of increasing salinity level. Also, leaf area influenced significantly by salinity. Moreover, increment of salinity concentration significantly declined root fresh and dry weight. Moreover, salinity reduces the fruit weight and oil content of olive (Chartzoulakis, 2005). Finally, Farzaneh et al., (2017) suggested that salt injury symptoms were negatively correlated with relative water content, leaf chlorophyll and nutrients content. In this sense, adopted advanced approaches to mitigate these adverse impacts of salinity is strongly required from several sides (maintaining old olive orchards, expanding olive cultivation in affected regions with salinity, raising efficiency of soil and water resources utilization) (Ben-Gal, 2011).

In the light of fact that salinity is a big barrier and one of the major environmental tresses affecting crop production worldwide, costing about $27 Bln /year in losses in agricultural sector and little of success trial to improve salinity tolerance of crops for sustainable food production, utilizing signaling molecule (i.e. Salicylic acid (SA)) to participate in defense responses against variety of environmental stresses including salinity considered an effective tool (Maheswari *et al.,* 2015).

Salicylic acid (SA) is a phenolic compound (Raskin et al., 1990). SA has been recognized as a regulatory signal mediating plant response to abiotic stresses such as salinity and drought (Munné-Bosch and Peñuelas, 2003; Chini et al., 2004), chilling (Janda et al., 1999; Kang and Saltveit 2002), heavy metal tolerance (Metwally et al., 2003; Yang et al., 2003; Freeman et al., 2005), heat (Larkindale and Knight, 2002; Larkindale et al., 2005), and osmotic stress (Borsani et al., 2001). SA has several fetal roles in plants, SA could contribute to maintaining cellular redox homeostasis through the regulation of antioxidant enzymes activity (Durner and Klessig, 1995, 1996; Slaymaker et al., 2002), induction of the alternative respiratory pathway (Moore *et al.*, 2002), and to regulating gene expression by inducing an RNA dependent RNA polymerase that is important for posttranscriptional gene silencing (Xie et al., 2001).

Aforementioned of considerable reasons, current study carried out to test theory concerning with signaling molecules (i.e. SA) can be an effective tool to avoid adverse impacts of abiotic stress (i.e. salinity).

MATERIALS AND METHODS

Current work had been conducted in greenhouse of Pomology Dept., National research Centre during two growth seasons (2016-2017) and data was represented as average of two seasons.

Plant material and treatments

Picual olive seedlings (40 cm) grown in greenhouse of Pomology Department, National Research centre were subjected to current experiment and these seedlings were fertilized according to the recommendation of the Ministry of Agriculture from March till October (growth season).

Salinity treatments

Salt solution comprised from (3 NaCl: 1 (1 $MgCl_2$: 1 $CaCl_2$), olive seedlings were irrigated with this salt solution at (6000 ppm)and control treatment irrigated with from tap water.

Antioxidant treatments

Salicylic acid (SA)used as antioxidant which applied in several doses (0, 200, 400 ppm) whether as foliar or soil application every 15 days from March till October (growth season) as shown in the following Table (1):

Treatments were arranged in randomized complete block design with five replicates for each treatment and each replicate was represented by three seedlings. At the end of October, plants of each treatment were removed genteelly with their root system to estimate and record the following data:

Vegetative growth parameters:

seedling height increment % which was calculated monthly after month of each spray and at the end of experiment (at the end of September)

1- Leaf fresh weight
2- Leaf dry weight
3- Root growth parameters:
4- Root length
5- Root fresh weight
6- Root dry weight

Leaves mineral content:

Nitrogen (N) and phosphorus (P) in leaves were calorimetrically determined according to the methods described by Bremner and Mulvaney (1982) and Olsen and Sommers (1982**)**, respectively. Potassium (K) was determined flame photometrically according to the method advocated by Jackson (1970).

Data Analysis:

The data were subjected to analysis of variance and the method of Duncan's was used to differentiate means (Duncan, 1959).

Table (1): SA treatments in presence or absence salt solution (6000ppm).

No	Salicylic acid (SA) treatments	Salinity treatments
1	Free- SA	Irrigation with tap water
2	SA as foliar application at 200ppm /15days	
3	SA as foliar application at 400ppm /15days	
4	SA as Soil application at 200ppm /15days	
5	SA as soil application at 400ppm /15days	
6	SA foliar application at 200 ppm /15 days + SA soil application 200ppm/15 days	
7	SA foliar application at 200 ppm /15 day + SA soil application 400ppm/15 days	
8	SA foliar application at 400 ppm /15 days + SA soil application 200ppm/15 days	
9	SA foliar application at 400 ppm /15 days + SA soil application 400ppm/15 days	
10	Free- SA	Irrigation with salt solution at 6000ppm
11	SA as foliar application at 200ppm /15days	
12	SA as foliar application at 400ppm /15days	
13	SA as Soil application at 200ppm /15days	
14	SA as soil application at 400ppm /15days	
15	SA foliar application at 200 ppm /15 days + SA soil application 200ppm/15 days	
16	SA foliar application at 200 ppm /15 days + SA soil application 400ppm/15 days	
17	SA foliar application at 400 ppm /15 days + SA soil application 200ppm/15 days	
18	SA foliar application at 400 ppm /15 days + SA soil application 400ppm/15 days	

RESULTS

In fact of, SA may be an effective therapeutic agent or mitigating agent for adverse effects of abiotic stress (drought and salinity) that was proved by several studies which indicated that SA may play a crucial role in regulating physiological and biochemical processes through lifespan of plant, data in Table (2) indicate that plant length was higher when olive seedling irrigated with tap water in comparison to those irrigated saline solution (80.63 and 73.56 respectively). Moreover, the highest value of plant height was obtained when SA applied at (400ppm as foliar application + 400 ppm as soil application) (84.17) comparing with other treatments and the lowest plant height produced with control whereas olive seedlings sprayed with tap water. Also, treating olive seedlings (in absence of salinity condition) with SA increased plant height, and these increments were raised with increasing concentration of SA. In regard to effect t of SA in presence of Salt solution at (6000 ppm), it can be noticed that, SA can relieve the effect of salinity, and this effect of SA was raised with increasing concentration of SA. Besides, foliar application didn't differ than soil application individually. Meanwhile gathering foliar application with soil application reinforced the impact of SA whether in presence or absence of saline solution. The obtained results were in harmony with those obtained by (Gutiérrez-Coronado et al., 1998) on soybean, (Shakirova et al., 2003) on wheat, (Gunes et al., 2007) on maize, and (Kovàcik et al., 2009) on chamomile.

Hussein et al., (2007) indicated that salinity reduced plant height in maize and spraying plants with salicylic acid in the rate of 200 ppm improved all growth characters i.e. plant height.

A positive impact of SA application on growth may be attributed to differ in the hormonal status (Shakirova et al., 2003; Abreu and Munne´-Bosch, 2009) or by enhancing in in photosynthesis, transpiration, and stomatal conductance (Stevens et al., 2006) which reflected positively on growth performance.

Meanwhile, the situation will be differed in presence of salt solution at 6000 ppm, whereas the positive impact of SA application may be attributed to its role in providing protection against salinity in plants, through activation of aldose reductase and APx enzymes and increasing the accumulation of osmolytes, such as sugars, sugar alcohol or proline (Tari et al., 2002, 2004;Szepesi et al., 2005). Besides Hayat et al., (2010) reported that with SA application, the oxidative damage that resulted under abiotic stress may be mitigated by inducing antioxidant scavenging system.

Recorded data in Table (3) showed that leaf number significantly decreased as a result of presence salinity stress. However, effect of SA treatments on number of leaves had no cleared trend, whereas the highest number of leaves produced with Appling SA in soil at 200ppm, meanwhile increased SA concentration in soil reduced this number. Also, foliar application didn't surpass soil application. Besides, integration foliar and soil applications didn't reinforced SA impact on leaf number. The lowest value of leaf number didn't accrue with control treatment but in presence of SA as foliar and soil application (foliar 200 ppm + soil 400 ppm). In regard to effect of SA on mitigation salinity adverse effects, it could noticed that, the highest number of leave produced with applied SA in soil at (200ppm) in presence of salinity at 6000ppm and not in absence of it.Current results were agreed with what obtained by Moursy et al., (2007) who reported that salinity reduced leaf number in maize. However, spraying plants with salicylic acid in the rate of 200 ppm improved all growth characters i.e. number and area of green leaves.

Table (4) shows that number of shoot was higher when olive seedling were irrigated with tap water comparison with those irrigated with saline solution at 6000 ppm. Also, SA had a positive effect on shoot number whereas, treating olive seedlings with SA whether as foliar or soil or even combining both of them (soil and foliar applications) almost increased shoot number comparing with control treatment, whereas the lowest of shoot number produced with control treatment. In respect to effect of SA on alleviation salinity adverse effects on olive seedling, It could noticed that in absence of salinity, SA resulted in the highest number of shoots comparing with in presence of salinity. Moreover, impact of SA on alleviation of salinity effect was noticeable for olive seedlings that received SA application as foliar or soil application or even combining both of them. However, it was conspicuous, SA as foliar application surpassed other SA treatments (soil application of combining foliar and soil application). In presence of salinity, the highest values of shoot number were recorded when SA applied as foliar application at 200 ppm (11.33) followed with SA at 400 ppm as foliar application. Besides, impact of SA treatments as soil application on shoot number came in second rank after SA as foliar application in presence of salinity. Meanwhile, combining SA as foliar and soil application didn't reinforced this impact of SA in presence of salinity.

These results came in same line of several reports that stated the promoting effect of SA in in absence on abiotic stress as hormone-like substance (Elhindi et al., 2017) or in present abiotic stress whereas studies of Khodary, (2004), Hussein et al., (2007) and Gunes et al.,(2007) showed that, the pronounced ameliorative impact of SA under saline condition may be referred to effect of SA on alleviating the imposed salt stress, either via osmotic adjustment or by conferring desiccation or salinity resistance to plant cells.

Also, in Table (5), data reveal that, salinity reduced dry matter of leaves. Also, SA application in all methods increased leaf dry matter comparing with control treatment. In respect of effect of SA on alleviation salinity adverse effects, all SA treatments improved situation of leaf dry matter under salinity conditions. However, the highest value of leaf dry matter in under salinity condition produced when SA applied as soil application at 400 ppm. Other SA treatments meritoriously neutralize the adverse effect of salinity relatively. These results were in harmony with what found by (Farhan et al., 2017) who reported that salinity showed pronounced reduction in the dry mass of the shoots and roots. However, SA treatment significantly increased the dry mass.

Moursy et al., (2007) showed that dry matter decreased with increasing salinity stress. Meanwhile, spraying plants with salicylic acid in the rate of 200 ppm improved all growth characters including dry weight of stem, leaves and whole plant. Moreover, many investigations indicated that, the ability to mitigate of salinity stress by exogenous SA had been proved. Arfan et al., (2007) and Li et al., (2014), recounted that spraying SA could balance direct salt stress actuated development restraint, while no change happened at high convergences of salt stress.

Data elucidated in Table (7) indicated that salinity at 6000ppm increased N content in leaves, and SA treatments also improved nitrogen content in leaves. The highest value of leaf nitrogen content noticed when olive seedlings were treated with SA either as soil application at 200 ppm or foliar application at 400ppm. Under salinity condition, data revealed that SA markedly enhanced nitrogen content particularly when olive seedlings treated with SA (Spring 200 ppm + soil 200 ppm) and (Spring 200 ppm + soil 400 ppm). Increasing nitrogen under salinity stress may be attributed to impact of salinity in reduction leaf area and dry matter and increasing uptake water with its contain of mineral as a consequences of increasing osmotic pressure in root zone.

Meanwhile, treating olive seedling with SA under salinity condition may be lead to balance of osmotic potential, induction of compatible osmolyte metabolism, and alleviating membrane damage (Mimouni et al., 2016).A Positive effects of SA on the ion uptake and inhibitory effects on Na uptake should also be responsible for managing salinity of sweet basil plants

(Mohammadzadeh et al., 2013).

Table (2): Effect of spraying picual olive seedlings with SA on plant height in presence or absence of high salinity in irrigation water.

Salinity Salicylic acid	Without salinity	6000 ppm	Mean
0 ppm	74.33cde	57.67 f	66.00 E
Spring 200 ppm	76.33bcd	76.00bcde	76.17 BCD
Spring 400 ppm	87.00 b	77.67bcd	82.33 AB
Soil treatment 200 ppm	75.67bcde	73.33cde	74.50 CD
Soil treatment 400 ppm	64.33ef	78.33	71.33 DE
Spring 200 ppm + Soil treatment 200 ppm	79.33bcd	79.33bcd	79.33 ABC
Spring 200 ppm + Soil treatment 400 ppm	82.67bc	70.67 de	76.67 ABCD
Spring 400 ppm + Soil treatment 200 ppm	86.67 b	80.00bcd	83.33 AB
Spring 400 ppm + Soil treatment 400 ppm	99.33 a	69.00 de	84.17 A
Mean	80.63 A'	73.56 B'	

Table (3): Effect of spraying picual olive seedlings with SA on leaf number/seedling in presence or absence of high salinity in irrigation water

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Salinity Salicylic acid	Without salinity	6000 ppm	Mean
0 ppm	253.00 cde	171.00 fg	212.00 D
Spring 200 ppm	264.00 cd	219.67 def	241.83 CD
Spring 400 ppm	356.67 b	241.67 cde	299.17 B
Soil treatment 200 ppm	350.00 b	480.00 a	415.00 A
Soil treatment 400 ppm	291.67 c	208.33 def	250.00 C
Spring 200 ppm + Soil treatment 200 ppm	293.67 c	201.67 efg	247.67 C
Spring 200 ppm + Soil treatment 400 ppm	161.00 g	180.00 fg	170.50 E
Spring 400 ppm + Soil treatment treatment200 ppm	156.00 g	196.00 efg	176.00 E
Spring 400 ppm + Soil treatment 400 ppm	225.33 def	161.67 g	193.50 DE
Mean	261.26 A'	228.89 B'	

Table (4): Effect of spraying picual olive seedlings with SA on shoot number in presence or absence of high salinity in irrigation water.

Salinity Salicylic acid	Without salinity	6000 ppm	Mean
0 ppm	6.00 h	5.33 h	5.67 C
Spring 200 ppm	6.67 fgh	11.33 abc	9.00A
Spring 400 ppm	9.33 bcdefg	10.00 bcde	9.67 A
Soil treatment 200 ppm	7.33 efgh	9.67 bcdef	8.50 AB
Soil treatment 400 ppm	11.00 abcd	7.67 efgh	9.33 A
Spring 200 ppm + Soil treatment 200 ppm	13.33 a	5.33 h	9.33 A
Spring 200 ppm + Soil treatment 400 ppm	8.00 defgh	5.33 h	6.67 BC
Spring 400 ppm + Soil treatment treatment200 ppm	7.67 efgh	8.33 cdefgh	8.00 BC
Spring 400 ppm + Soil treatment 400 ppm	11.67 ab	6.33 gh	9.00 A
Mean	9.00 A'	7.70 B'	

Table (5): Effect of spraying picual olive seedlings with SA on leaf dry weight in presence or absence of high salinity in irrigation water.

Salinity Salicylic acid	Without salinity	6000 ppm	Mean
0 ppm	64.17 j	63.70 j	63.94 E
Spring 200 ppm	67.87 fg	64.38 ij	66.13 D
Spring 400 ppm	67.21 g	64.22 j	65.72 D
Soil treatment 200 ppm	71.07 c	65.18 hi	68.13 B
Soil treatment 400 ppm	74.75 b	77.43 a	76.09 A
Spring 200 ppm + Soil treatment 200 ppm	69.15 de	67.22 g	68.19 B
Spring 200 ppm + Soil treatment 400 ppm	64.06 j	67.08 g	65.57 D
Spring 400 ppm + Soil treatment treatment200 ppm	69.74 d	65.17 hi	67.46 C
Spring 400 ppm + Soil treatment 400 ppm	68.43 ef	65.62 h	67.03 C
Mean	68.50 A'	66.67 B'	

Table (6): Effect of spraying picual olive seedlings with SA on leaf water content in presence or absence of high salinity in irrigation water

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Salinity Salicylic acid	Without salinity	6000 ppm	Mean
0 ppm	35.83 a	36.30 a	36.06 A
Spring 200 ppm	32.13 de	35.62 ab	33.87 B
Spring 400 ppm	32.79 d	35.78 a	34.28 B
Soil treatment 200 ppm	28.93 h	34.82 bc	31.87 D
Soil treatment 400 ppm	25.25 i	22.57 j	23.91 E
Spring 200 ppm + Soil treatment 200 ppm	30.85 fg	32.78 d	31.81 D
Spring 200 ppm + Soil treatment 400 ppm	35.94 a	32.92 d	34.43 B
Spring 400 ppm + Soil treatment treatment200 ppm	30.26 g	34.83 bc	32.54 C
Spring 400 ppm + Soil treatment 400 ppm	31.57 ef	34.38 c	32.97 C
Mean	31.50 B'	33.33 A'	

Table (7): Effect of spraying picual olive seedlings with SA on leaf Nitrogen content in presence or absence of high salinity in irrigation water.

Salinity Salicylic acid	Without salinity	6000 ppm	Mean
0 ppm	1.68 i	2.20 ef	1.94 E
Spring 200 ppm	1.97 h	2.05 gh	2.01 D
Spring 400 ppm	2.21 def	2.11 fg	2.16 C
Soil treatment 200 ppm	2.35 abc	2.43 a	2.39 A
Soil treatment 400 ppm	2.13 fg	2.42 ab	2.27 B
Spring 200 ppm + Soil treatment 200 ppm	2.35 abc	2.45 a	2.40 A
Spring 200 ppm + Soil treatment 400 ppm	2.17 ef	2.45 a	2.31 B
Spring 400 ppm + Soil treatment treatment200 ppm	2.45 a	1.77 i	2.11 C
Spring 400 ppm + Soil treatment 400 ppm	2.26 cde	2.31 bcd	2.28 B
Mean	2.20B'	2.24 A'	

Table (8): Effect of spraying picual olive seedlings with SA on leaf phosphorus content in presence or absence of high salinity in irrigation water.

Salinity Salicylic acid	Without salinity	6000 ppm	Mean
0 ppm	0.033 a	0.059 a	0.045 AB
Spring 200 ppm	0.033 a	0.045 a	0.039 B
Spring 400 ppm	0.037 a	0.095 a	0.066 A
Soil treatment 200 ppm	0.049 a	0.039 a	0.044 AB
Soil treatment 400 ppm	0.042 a	0.046 a	0.044 AB
Spring 200 ppm + Soil treatment 200 ppm	0.039 a	0.043 a	0.041 B
Spring 200 ppm + Soil treatment 400 ppm	0.049 a	0.051 a	0.050 AB
Spring 400 ppm + Soil treatment treatmen t200 ppm	0.046 a	0.054 a	0.050 AB
Spring 400 ppm + Soil treatment 400 ppm	0.039 a	0.042 a	0.040 B
Mean	0.041 B'	0.050 A'	
Mean	0.041 B'	0.050 A'	

Table (9): Effect of spraying picual olive seedlings with SA on leaf potassium content in presence or absence of high salinity in irrigation water

Salinity Salicylic acid	Without salinity	6000 ppm	Mean
0 ppm	1.11 de	0.86 j	0.98 E
Spring 200 ppm	1.11 de	1.08 ef	1.10 BC
Spring 400 ppm	1.15 cd	0.92 j	1.04 D
Soil treatment 200 ppm	1.24 b	1.03 fghi	1.13 B
Soil treatment 400 ppm	1.31 a	0.91 j	1.11 BC
Spring 200 ppm + Soil treatment 200 ppm	1.01 ghi	0.98 i	1.00 DE
Spring 200 ppm + Soil treatment 400 ppm	1.06 efgh	1.33 a	1.19 A
Spring 400 ppm + Soil treatment treatment 200 ppm	1.18 c	1.00 hi	1.09 C
Spring 400 ppm + Soil treatment 400 ppm	1.01 ghi	1.06 efg	1.03 D
Mean	1.13 A'	1.02 B'	

Data in Table (8) indicated that leaf phosphorus didn't changed significantly with applying SA neither as foliar application nor as soil application. Meanwhile olive seedlings under salinity were recorded higher phosphorus content. Gunes et al., (2005) determined that SA supply inhibited the Na accumulation, but stimulated N, P, K, Mg, Fe, Mn, and Cu uptakes by salt-stressed maize plants compared to non-treated ones. They explained that the positive effect of SA on growth of salt-stressed plants could be attributed to decreasing levels of Na and Cl concentrations and increasing antioxidant activity. Data in Table (9) indicated that salinity had a negative impact on uptake potassium that lead to decrease leaf K content. Also, treating plant with SA that irrigated with tap water resulted in increasing Potassium content and the highest value was obtained when olive seedling received SA at 400 ppm in soil. Besides, treating olive seedlings with SA under salinity condition at 6000 ppm had a positive impact and the highest value of potassium content under salinity stress was obtained when olive seedling treated with SA at (200 ppm as foliar application + 400ppm as soil application). These results were the same line of what found by Lopez- Al-Hakimi and Hamada (2001) also observed similar effects of SA on the Na, K, Ca, and Mg contents of wheat plants grown under salinity.

Generally, Under abiotic stress (i. e. Salinity) and increasing reactive oxygen species (ROS) generation, plants have an effective defense system composed of both, enzymatic and non-enzymatic (and antioxidants systems. Current study comes to support the role of SA in mitigating adverse effects of abiotic stress (i.e. salinity) through either via osmotic adjustment, regulation of antioxidant enzymes activity. SA is a phenolic growth regulator which assumes conspicuous and expanded role in biochemical and physiological reaction to abiotic stress. Several studies indicated for positive impacts of treating plants with SA. These studies mentioned that foliar SA applications increased significantly growth parameters of sweet basil compared to the control under both the absence and the presence of salt stress in the study. Also, foliar application of SA to sweet basil effectively alleviated NaCl-induced growth inhibition and toxicity in sweet basil seedlings, indicating SA ability to prevent inhibition of the relative growth rate. This positive effect of SA could be related to an increased CO2 assimilation and photosynthetic rate and increased mineral uptake by the stressed plant under SA treatment (Khan,et al.,2003). Moreover, improvement of antioxidant activity and protective role of membranes caused by SA application increased the plant's tolerance to damage (Turan and Aydin 2005). The similar result was reported by Bayat, et al., (2012), Mohammadzadeh et al., (2013) and Sumaira et al., (2014).

Farhan et al., (2017) demonstrated that application of SA can meritoriously neutralize the adverse effect of moderate saline conditions on growth and development of *Pisum sativum*. Moreover, several studies indicated that SA can reduce the destructive effects of several abiotic stresses by regulating proline concentration and other osmolytes production (Chandrakar et al., 2016 Ma et al., 2017).It has been also revealed that exogenously applications of SA can significantly enhanced overall growth of plant under both salinity and non-salinity by adjusting antioxidants scavenging system (Ismail 2013). Moreover, the oxidative damage caused to the plants due to the increased generation of reactive oxygen species under stressful environment could be mitigated by the exogenous application of SA (Hayat et al., 2010). Also, SA application is known to increase the endogenous osmolyte content (Hayat et al., 2010).

CONCLUSION

It has been revealed that exogenous applications of SA can significantly enhance overall growth of plant under both salinity and non-salinity by adjusting antioxidants scavenging system. Moreover, the oxidative damage caused to the plants due to the increased generation of reactive oxygen species under stressful environment could be mitigated by the exogenous application of SA. Also, SA applications is known to increase endogenous osmolyte content.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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