Effect of Salicylic Acid On Growth, Yield, Nutritional Status and Physiological Properties of Sunflower Plant Under Salinity Stress

Refat A.Youssef[1], Mona E. El-Azab[1], Hayam A. A. Mahdy[2],Entsar M. Essa[3] and Kassem A. S. Mohammed[3]

[1]Soils and Water Use Department, National Research Centre, Dokki, Giza, Egypt.
[2]BotanyDepartment, National Research Centre, Dokki, Giza, Egypt.
[3]Plant nutrition Department, National Research Centre, Dokki, Giza, Egypt.

ABSTRACT

A field experiment was conducted in soil affected by different levels of salinity, to illustrate the effect of salicylic acid on growth, yield, nutritional status and physiological properties of Sunflower(Helianthus annuus L., cv Sakha-53) plants. Three site of soil differed in salinity were chosen, and which the levels were (4, 7 and 12 dS m-1). Three rates of salicylic acid (0, 0.7 and 1.4 mM) were sprayed on plants twice at 30 and 45 days from sowing.

The results indicated that increasing the rate of salicylic acid from 0 to 1.4 mM led to increasing significantly leaf area, plant height and all yield components of sunflower plants under all levels of soil salinity. Increasing salicylic acid levels had a positive effect of all physiological compositions. Under high levels of salicylic acid 1.4 mM was given high values of physiological compositions (chlorophyll a and b, carotenoids, total carbohydrate, protein content and proline). Increasing soil salinity levels from 4 to 12 dS m-1led to clearly decreasing nutrients uptake of leaves.While splattering salicylic acid on leaves helped on enhancing all nutrients uptake. Splattering salicylic acid on plants led to increasing all Na ratios (K/Na, Ca/Na and Mg/Na) because salicylic acid alleviated the salinity stress on plants, as well as enhancing nutrients uptake.

It could be deduced that salicylic acid was played important role to mitigated salinity stress on sunflower plants which grown under different levels of soil salinity. As well as salicylic acid has effective role under high salinity conditions to enhancing tolerance of plants to this salinity.

Key Words: Sunflower, Saline soil, Salicylic acid, Growth, Yield components, Physiological properties, Nutritional status.

eIJPPR 2017; 7(5):54-58

HOW TO CITE THIS ARTICLE: Refat A Youssef, Mona E. El-Azab, Hayam A. A. Mahdy, Entsar M. Essa and Kassem A. S. Mohammed (2017): Effect of Salicylic acid on growth, yield, nutritional status and physiological properties of Sunflower plant under salinity stress.*International Journal of Pharmaceutical and Phytopharmacological Research, 7*(5), pp.54-58.

INTRODUCTION

Salt stress was one of the most serious defining factors for crop development and production in the arid zones, and about 23% of the world's cultivated soils is saline [1]. Under saline soil conditions, the salts were negatively affect on a plants growth; because high concentration of salts led to decrease water absorption, andit was led to ion imbalance and it was resulted in plant toxicity [2]. Salt stress critically influences the physiological processes and morphological composition of plants, so that lead to decreasing of plant growth [3].

Strategies for mitigation of salt stress involve evolving salt resistant cultivars, leaching excess soluble salts from layers of soil, flushing soils that contain salt crusts at the surface, reducing salt by harvesting salt accumulating aerial plant parts in areas with negligible irrigation water or rainfall for

Corresponding author: Refat A. Youssef
Address: Soils and Water Use Department, National Research Centre, Dokki, Giza, Egypt.
e-mail refatay@gmail.com
Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
Received: 11 October 2016; **Revised:** 14 June 2017; **Accepted:** 28 July 2017

leaching, and amelioration of saline soils under cropping and leaching [4].

Salicylic acid was a colorless crystalline organic acid, and it was openly hired in organic compositions and functions as a plant hormone. Salicylic acid was a phenolic phytohormone and was organize in plants with roles in plant growth and development, photosynthesis, transpiration, ion uptake and transport [5]. Salicylic acid was a signaling compound that played a vigorous role in plant restraint to biotic and abiotic stress such as heat, low temperature and salt stress [6] .Sprayingplants with salicylic acid has effective role for potential growth regulator improving plant resistance to high salinity stress [7].

This work destined to explore the echo of sunflower plants (*Helianthus annuus* L., cv Sakha-53) grown under saline soil conditions to implementation of different concentrations of salicylic acid.

MATERIAL AND METHODS:

A field experiment was conducted on saline affected soil at Tamia District,Fayoum Governorate by cultivating sunflower(*Helianthus annuus* L., cv Sakha-53) plants in the summer season of 2015.The experiment was carried out in a randomized complete block design, with three replicates. Interaction effects of different rates of salicylic acid and various levels of soil salinity on yield components, physiological compositions and nutrients uptake of sunflowers plants. Three rates of salicylic acid (0, 0.7 and 1.4 mM) were sprayed on plants twice at 30 and 45 days from sowing. Three soil sites differed in their salinity were chosen to sowing sunflower. The field of experiment was sampled before pepper planting to determine some chemical properties according to the standard procedures outlined by Cottenie [8] are scheduled in Table (1).

Table (1): Some chemical properties of the soil used.

Experimental sites	PH (1:2.5)	EC (dSm^{-1})	Organic matter %	$CaCO_3$ %	Soluble cationsmeq/l				Soluble anions meq/l			
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3	HCO_3	Cl^{-}	SO_4^{--}
No. 1	7.60	4	0.93	7.76	2.1	2.04	35.4	0.46	-	0.5	34.30	5.20
No. 2	7.90	7	0.82	9.10	8.80	3.27	72.67	2.46	-	1.66	73.1	12.4
No. 3	7.92	12	0.64	9.62	10.04	4.6	132.8	2.56	-	1.16	125.3	23.54

One N, P and K fertilization rate (200 Kg N, 200 kg P_2O_5 and 48 kg K_2Ofed^{-1}) in the form of ammonium nitrate, superphosphate and potassium sulfate, respectively.

Plant samples were dried at 65 C° for 48 hrs to be then ground and wet digested using H_2SO_4: H_2O_2 method described by Cotteine [8].The digests were then subjected to measurement of N using micro Kjeldahl method; P was assayed using molybdenum blue method while K and Na were evaluated by flame photometer, but and Caand Mg were determined using atomic absorption spectrophotometer [9]**.**While Cl was determined according toCotteine [8],Total soluble protein in seeds was determined according to Bradford [10] and total carbohydrates in seeds were measured according to A.O.A.C**.** [11]. Chlorophyll a, b and carotenoids were determined in fresh leaves of sunflower plants according to the methods described by Wettstein [13]. Proline determined calorimetrically using ninhydrin reagent according to Bates *et al.* [13].

RESULTS AND DISCUSSION:

Data in Table (2) showed that, the effect of salicylic acid rates (0, 0.7 and 1.4 mM) on growth and yield ingredients of sunflower plants grown on various levels of soil salinity (4, 7 and 12 dS m^{-1}). Increasing the level of soil salinity from 4 to 12 dS m^{-1} causes significant decline in both growth and yield ingredients of sunflower plant. While, increasing the rate of salicylic acid from 0 to 1.4 mM led to increasing significantly leaf area, plant height and all yield ingredients of sunflower plants under all levels of soil salinity. High rate of organic acid (1.4 mM) was helped greatly to reduce the effects of soil salinity on all parameters of growth and yield parameters of sunflower plants. Salicylic acid played effective role in saline stress tolerance because it was capability to motivate a protective effect on plants under salinity condition [14]. Eraslan *et al.* [15] showed that spraying salicylic acid led to enhancing growth, physiological process of carrot plants germinated under salinity stress. Kováčik*et al.* [16] indicated that spraying salicylic acid (500 uM/L) on leaves of plants could significantly increase plant growth parameters under saline condition. Salicylic acid was a phenolic substance; phenols were defined as compounds with a hydroxyl group with active derivatives [5]. Ma *et al.*, [3] found that the affirmative act of salicylic acid in decreasing of salinity exertion was based on salt concentration and plant species. Obtained data (Table,3) clearly indicated that the same improved effect of salicylic acid on growth and yield ingredients, also appearing on physiological compositions of sunflower plants. Increasing salicylic acid levels from 0 to 1.4 mM had a positive effect of all physiological compositions; this was true under all soil salinity levels. High rate of salicylic acid was given high values of physiological compositions (chlorophyll a and b, carotenoids, total carbohydrate, protein content and proline); especially proline, which has an affirmative role in increasing the ability of plants to afford salinity.

Table (2): Effect of salicylic acid rates on growth and yield components of sunflower plants grown on various levels of soil salinity

Salinity levels	Salicylic acid	Leaf area	Plant height	Head diameter	Seedweight/head	Seed index	Seed yield	Seed oil content
ds m^{-1}	mM	cm^2	cm		g		ton fed^{-1}	%
4	0	10.60	79.22	13.70	28.12	5.70	0.70	30.12
	0.7	12.8	129.2	17.80	37.94	6.00	0.93	31.16
	1.4	15.70	153.3	18.10	39.19	6.22	0.96	31.34
7	0	7.130	65.00	11.10	19.55	4.74	0.57	19.35
	0.7	10.60	80.44	12.80	23.96	4.90	0.68	22.28
	1.4	12.50	119.6	13.20	25.74	5.24	0.73	23.59
12	0	4.930	58.34	7.900	16.20	3.66	0.49	18.28
	0.7	7.610	73.00	9.410	19.82	4.26	0.58	18.95
	1.4	10.20	89.50	9.800	20.82	4.46	0.50	19.54
LSD $_{0.05}$		0.534	4.36	0.41	0.55	0.13	0.02	0.40

Table (3): Effect of salicylic acid on some physiological compositions of sunflower plants grown on different levels of soil salinity.

Salinity levels	Salicylic acid rates	Chlorophyll (a)	Chlorophyll (b)	Carotenoids	Total carbohydrate	Protein content	Proline
dS m^{-1}	mM	mg g^{-1}	mg g^{-1}	mg g^{-1}	%	%	mg g^{-1}
4	0	0.87	0.43	0.33	17.0	12.6	0.20
	0.7	0.99	0.49	0.38	18.0	13.6	0.20
	1.4	0.99	0.49	0.42	18.1	14.2	0.23
7	0	0.80	0.40	0.28	14.0	12.1	0.24
	0.7	0.90	0.45	0.34	13.8	12.6	0.25
	1.4	0.90	0.45	0.37	14.7	13.5	0.27
12	0	0.70	0.35	0.25	13.0	9.73	0.25
	0.7	0.75	0.38	0.27	13.7	10.2	0.28
	1.4	0.83	0.41	0.30	14.3	10.8	0.32
LSD $_{0.05}$		0.02	0.01	0.012	0.147	0.143	0.012

Parida and Das [17] showed that chlorophyll content of leaves was decreased under salt stress because of adverse effects of ions of various salts in chlorophyll biosynthesis.As well as salinity effect on chlorophyll content by stopping certain enzymes accountable for assembly of green pigments in plants [18]. Spraying salicylic acid on leaves whichwere grown in saline soil led to increasing the content of chlorophyll in bean plants [19].The decreasing in protein content in plants under abiotic stress might be due to the reducingavailability of amino acids and deformation of enzymes that were necessary in the synthesis of amino acids and proteins [4].Arfan [20] indicated that the protein content in plants was significantly increased under salinity stress when salicylic acid was applied. Spraying salicylic acid on plants under saline condition was led to enhancing proline content in plants [4]. Thestimulation effect of salicylic acid on thebiosynthesis of soluble sugars andproteins was associated to an increase in photosynthetic pigments and consequently the photosynthetic system [21].

Obtained data (Table, 3) clearly indicated that increasing soil salinity levels from 4 to 12 dS m^{-1}led to clearly decreasing nutrients uptake of leaves, while splashing salicylic acid on leaves was helped on enhancing all nutrients uptake because the role of salicylic acid in increasing dry matter of plants.The values of N, P, K, Ca, Mg and Na uptake (Opposite to Cl uptake value) were high valuesunder low level of soil salinity (4dS m^{-1}) compared with the higher levels of soil salinity. Although the effectiveact of salicylic acid on increasing of all nutrients uptake, but this effective role of salicylic acid clearly appeared on K uptake values; thus reducing the deleterious effect of sodium ions in plant tissues.

Increasing salinity levels of soils led to increasing concentrations of Na^+ and Cl^- and reducing concentrations of K^+, Ca^{2+} and Mg^{2+} in many plant species [22].Wahid *et al.*, [23] showed that the uptake of N uptake was often disrupted under salt stress, as well as excess salts could reduce the accumulation of N in plant because the antagonism between Cl^- and $NO_3^=$. Gunes *et al.*, [24] reported that salicylic acid minimize the Na uptake of

ISSN (Online) 2249-6084 (Print) 2250-1029

plants and raised the uptake of N, P, K, Ca and Mg as compared to control treatment under salt stress.

Data in Table (5) showed that raising salinity levels from 4 to 12 dS m^{-1} decreased the K/Na, Mg/Na and Ca/Na ratios. The lowest values of each of K/ Na, Mg/ Na and Ca/ Na ratioswere obtained byhigh values of soil salinity (12dS m^{-1}), but the moderate salinity (7 dS m^{-1}) enough to obtain minimal values of Ca/(Na+ K) ratio. While, splattering salicylic acid on plants led to increasing all Na ratios because salicylic acid alleviated the salinity stress on plants and enhancing nutrients uptake. High rate of salicylic acid 1.4mM could be given high values of K/Na, Mg/Na, Ca/Na and Ca/ (Na+ K)ratios.

Table (4):Effect of salicylic acid on nutrients uptake of leaves sunflower grown on different levels of soil salinity.

Salinity levels	Salicylic acid rates	Nutrients uptake mg/plant						
dS m^{-1}	mM	N	P	K	Ca	Mg	Na	Cl
4	0	20.1	1.52	17.2	8.18	3.94	10.5	3.23
	0.7	35.6	2.43	29.2	13.4	6.16	7.61	5.02
	1.4	35.9	4.00	46.6	21.0	8.62	5.25	6.78
7	0	10.6	0.81	8.70	5.22	2.94	10.6	2.84
	0.7	24.0	1.80	19.2	11.0	6.00	7.80	5.98
	1.4	34.6	2.48	28.1	15.8	8.25	3.83	7.59
12	0	6.24	0.51	4.84	3.78	2.14	5.85	3.47
	0.7	13.1	1.23	10.7	9.18	3.44	3.94	7.05
	1.4	22.6	2.13	18.5	15.6	5.85	1.95	9.58
$LSD_{0.05}$		2.32	0.52	1.40	2.50	0.84	2.20	1.55

Table (5):Effect of salicylic acid foliar spray and salinity on Na ratios concentration in leaves of sunflower plants.

Salinity levels	Salicylic acid rates	Na ratios			
dS m^{-1}	mM	K/Na	Mg/Na	Ca/Na	Ca/(Na+ K)
4	0	1.638	0.375	0.779	0.295
	0.7	3.837	0.809	1.761	0.364
	1.4	8.876	1.642	4.000	0.405
7	0	0.821	0.277	0.492	0.270
	0.7	3.282	1.026	1.880	0.407
	1.4	7.337	2.154	4.125	0.495
12	0	0.621	0.274	0.485	0.406
	0.7	2.716	0.873	2.330	0.627
	1.4	9.487	3.000	8.000	0.762

Essa [25] reported that high soil salinity may produce extreme ratios of Na/Ca and Na/K in the plants tissues, causingthem to be susceptible to osmotic, specific ion injury and to nutritional disorders. Karlidag*et al.*, [26] indicated that salicylic acid application inhibited Na accumulation, but stimulated N, P, K, Mg, Fe, Mn and Cu uptake. Hussein et al.,7 showed that salicylic acid affected on the Na ratios with K, Mg and Ca. Where K/Na, Mg/ Na and Ca/Na ratios increased by salicylic acid spraying and the reverse was only observed with Ca/ (K+Na) ratio, which decreased by 200 ppm salicylic acid application.

REFERENCES:

1 - Jouyban, Z. (2012). The effects of salt stress on plant growth. Tech J Engin& App Sci., 2 (1): 7-10.

2 - Roussos, P.; D. Gasparatos, C. Kyriakou, K. Tsichli, E. Tsantili and C. Haidouti (2013). Growth, nutrient status and biochemical changes in sour orange (*Citrus aurantium* L.) plants subjected to sodium chloride stress. Commun. Soil Sci. Plant Anal.44, 805–816.

3 - Ma X.; J. Zheng,J. Zhang, X. Zhang,Q. Hu and R. Qian (2017). Salicylic Acid Alleviates the Adverse Effects of Salt Stress on *Dianthus superbus* (Caryophyllaceae) by Activating Photosynthesis, Protecting Morphological Structure, and Enhancing the Antioxidant System. Front Plant Sci., 8:600-608.

4 - Hadi, H.; A. Najafabadi and R. Amirnia (2014).Comparison of different treatment methods of salicylic acid on some physiological traits of white bean under salinity stress.CercetăriAgronomice , 3:97-105.

5 - Nasrin M.; F. M.Nejad and H. Zeinali (2014).Effect of salicylic acid and salinity on some morphological characteristics of Aloe Vera.Ann.Bio. Sci., 2: 68-71.

6 - Kim Y.; S. Kim, and L. Shim (2017). Exogenous Salicylic Acid Alleviates Salt-Stress Damage in Cucumber underModerate Nitrogen Conditions by Controlling Endogenous Salicylic Acid Levels. Hortic. Environ. Biotechnol.3: 247-253.

7 - Hussein, M. M.; A. I. Rezk, A. B. El- Nashartyand H. M. Mehanna (2015). Nutritional and growth response of Canola plants to salicylic acid under salt stress conditions. Int.J. ChemTech Res. 8: 574-581.

8 - Cottenie, A. (1980).Soil and plant testing as a basis of fertilizer recommendation. F.A.O. Soil Bull.

9 - Chapman, H.D. and R.E. Pratt (1961). Methods of analysis for Soil, Plants and Water Dept. of Soil, Plant Nutrition, Univ. of California. U.S.A.

10 - Bradford, M. M. (1976). A rapid and sensitive method for the quantification of microgram quantities of proteinutilizing the principle of protein-dye binding.Anal.Biochem., 72 : 248.

11- A.O.A.C., (2005). Official methods of analysis.15th ed. Association of Official Agricultural Chemists. 12thEd.,Washington, D.C., USA.

12- Wettstein, D. (1957). Chlorophyll, letal und der submikrospischeformmech sell- der plastiden, Exptl. Cell. Res.,12-427.

13- Bates, L.S.; R.P. Waldren, and I.D. Teare (1973). Rapid determination of free proline for water stress studies. Plant and Soil, 39: 205-207.

14 - Sakhabutdinova A. R., Fatkhutdinova D. R., Bezrukova M.V. and F. M. Shakirova (2003). Salicylic acid prevents the damaging actions of stress factors on wheat plants. Bulgarian Journal of Plant Physiology, special issue, 314- 319.

15 - Eraslan, F.; A. Inal, A. Gunesand M. Alpaslan (2007). Impact of exogenous salicylic acid on growth, antioxidant activity and physiology of carrot plants subjected to combined salinity and boron toxicity. Sci. Hort., 113: 120-128.

16 - Kováčik, J.;J.Grúz, M. Bačkor, M. Strnad and M. Repčák (2009). Salicylic acid-induced changes to growth and phenolic metabolism in *Matricariachamomilla* plants. Plant Cell Rep. 28: 135–143.

17 - Parida, A. K. and A. B. Das (2005). Salt tolerance and salinity effects on plants: a review. Ecotoxicology and Environmental Safety, 60: 324-349.

18 - Gautam S. andP. K. Singh (2009).Salicylicacid induced salinity tolerance in corn grown under NaCl stress. ActaPhysiologiaePlantarum, 31: 1185-1190.

19 - Türkyilmaz, B.; L.Y.Aktaş and A. Güven (2005). Salicylic acid induced some biochemical and physiological changes in Phaseolus vulgaris L. Science and Engineering Journal of Firat. University, 17 : 319-326.

20-Arfan M., Athar H.R. and M. Ashraf (2007). Does exogenous application of salicylic acid through the rooting medium modulate growth and photosynthetic capacity in two differently adapted spring wheat cultivars under salt stress? Journal of Plant Physiology, 164: 685-694.

21- Yildirim, B.; F. Yaser, T. Ozpay, D. T. Ozpay, D.TurkozuO. Terziodluand A. Tamkoc (2008).Variations in response to salt stress among field pea genotypes (Pisumsativumsp.arvense L.). Journal of Animal and Veterinary Advances, 7: 907-910.

22-Bayuelo-Jimenez, J.S., D.G. Debouck and J. P. Lynch (2003).Growth, gas exchange, waterrelations, and ion composition of *Phaseolus*species grown under saline conditions.*Field Crops Research*, 80: 207-22.

23- Wahid, A.; M. Hameed and E. Rasul (2004). Salt-induced injury symptom, changes innutrient and pigment composition and yield characteristics of mungbean. International Journal of Agricultural Biology, 6: 1143–1152

24 - Gunes, A.; A. Inal, M.Alpaslan, F. Eraslan, E. G. Bagci and N. Cicek (2007). Salicylic acid induced changes onsome physiological parameters symptomatic for oxidative stressand mineral nutrition in maize (*Zea mays* L.) grown undersalinity. Journal of Plant Physiology, 164:728-736.

25 - Essa, T.A. (2002).Effect of salinity stress on growth and nutrient composition of three soybeans(Glycine max L. Merrill) cultivars. Journal of Agronomy and Crop Science, 188:86-93.

26 - Karlidag, H., E. Yildirim and M.Turan (2009). Salicylic acid ameliorates the adverse effect of saltstress on strawberry. Sci. Agric. (Piracicaba, Braz.).66: 180-187.

ISSN (Online) 2249-6084 (Print) 2250-1029