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Physiological Role of Salicylic Acid in Improving Growth and Productivity of Barley (*Hordeum vulgare* L.) Under Sandy Soil Conditions.

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ABSTRACT

Two field experiments were carried out in newly cultivated sandy soil at the Agriculture Experimental Station of National Research Center, Nubaria, Behira Converment, Egypt, in winter seasons of 2010/2011 and 2011/2012 on three – lss barley cultivars (Giza-129, Giza-130 and Giza-131 to study the physiological role of salicylic acid in improving growth and productivity of barley plant under sandy soil conditions.

The obtained results could be summarized as follows:

1- Barley cultivars significantly differed in growth characters at 80, 95 and 110 days after sowing and yield, as well as, yield components and protein and carbohydrates – per grains except crop index and harvest index at harvest date. Moreover, Giza-129, Giza-130 and Giza-131 barley cultivars significantly different in photosynthetic pigments content per blades and different in IAA, GA_3, IAA and cytokinin per shoot at 45 days age after sowing. Furthermore, Giza-131 was the best cultivar compared with Giza-129 and Giza-130 cultivars.

2- Soaking barley seeds with different concentration of salicylic acid caused significant increases in growth parameters and yield and its components and photosynthetic pigments content. Data show that the most effective treatment was 100 mg/l SA. In addition, SA caused a positive effect in content of endogenous hormons per plant shoot and the favourable concentration in this effect was 100 mg/l SA, also

3- The effect of the interaction between the three barley cultivars under study, i.e. Giza-129, Giza-130 and Giza-131 and the five concentrations of salicylic acid (0, 25, 50, 75 and 100 mg/l) was significant on growth characters, yield and its components (except crop index and migration coefficient) and photosynthetic pigments content.

It is worthy to mention that the most effective treatment for growth characters, yield and its components, photosynthetic pigment content and total carbohydrate and total crude protein percentages per grains and straw as well as endogenous plant growth promotores was Giza-131 treated with 100 mg/l salicylic acid.

Key words: Barley,salicylic acid,Growth , Productivity, sandy Soil

Introduction

Barley (*Hordem vulgare* L.) is considered to be one of the most important cereal crop in the world as well as in Egypt (FAO, 2007). In Egypt the national production of cereals is relatively lower than the consumption demands. It was suggested to use barley as a complementary cereal crop to minimize this gab because of barley's ability, compared with other cereal crops, to grow well under the drought conditions common to Egypt and it is mainly used to animal feeding (including both grain and straw) and bread making by bedowin people living in the desert and dry areas. Many produce showed that barley cultivars differ in growth parameters, yield and yield components (Noaman *et al.*, 1996, El-Bawab, 1998, El-Hadi *et al.*, 1998, El-Khaly and El-Bawab, 1998, Abd-Alla (2004), Abd El-Hameed and Ash-Shormilleys, 2005, Alberta, 2007, Shrbanek *et al.*, 2008, Hussein *et al.*, 2009 and Ahmed *et al.*, 2013).

Salicylic acid is an endogenous growth regulator of phenolic nature and acts as potential non-enzymatic antioxidant which participates in the regulation of many physiological processes in plants, such as stomatal closure, photosynthesis, ion uptake, inhibitor of ethylene biosynthesis, transpiration and stress tolerance (Khan *et al.*, 2003 and Arfan *et al.*, 2007). Salicylic acid is a tool to plant tolerance against the adverse effect of biotic and abiotic stresses (Bosch *et al.*, 2007) either by foliar application or seed treatment, since, it has a regulatory effect on activating biochemical pathways associated with tolerance mechanisms in plant (Najafian *et al.*, 2009).

The present work aimed to study the physiological role of salicylic acid in improving growth and productivity of barley (*Hordeum vulgare* L.) under sand soil conditions.

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Materials and Methods

The present study was carried at the Experimental Station of Agricultural Production and Research, National Research Center, El-Nubaria Province, El-Behaira Governorate., Egypt during two successive winter seasons (2010/2011 and 2011/2012).

Physical and chemical analysis of the experimental field soil were determined and included the following characters, sand 91.20%, silt 3.70%, clay 5.10%, P^H 7.80, organic meter 0.21%, $CaCo_3$ 1.00%, E.C. 0.50 mmhos/cm^3 and the available total N, P, K were 8.10, 3.20, 20.0 ppm, respectively at 0.60 cm depth as described by Chapman and Pratt (1978). Soil was ploughed twice, ridged and divided into plots during seed preparation 150 kg calcium super phosphate/fed. (15.5% P_2O_5) was added as a general application. Seed of three barely cultivars were obtained from Agricultural Research Center, Giza, Egypt namely Giza-129, Giza-130 and Giza-131). The seeds of the three cultivars soaked for 12h with different concentration of salicylic acid (0, 25, 50, 75 and 100 mg/l). then the seeds were air dried and sown in split-plot design with four replication in rows 3 meter long, 15 cm apart and 20 rows with total area (10.5 m^2). The cultivars were considered as a main plot and the concentration of salicylic acid (SA) as the sub-plots. Sowing took place on 20 and 22th November in 2010 and 2012; respectively; at a rate of 60 kg/fed. The normal agronomic practices of barley growth were followed until harvest as recommended by Barely Research Dept. Agriculture Research Center.

Growth Characters:-

Samples of ten guarded plants were taken at random of each plot to determine the growth parameters at 80, 95 and 110 days after sowing, where; plant height, tillers, leaves and spikes number/plant and dry weight of tillers + sheats, blades an spikes “g/plant” were measured. Flag leaf area “cm^2” and blades area “cm^2/plant” were determined according to Bremner and Taha (1966). Leaf area index (LAI) was estimated according to Watson (1992).

Yield Measurements:

Ten plants were randomly taken from the middle rows of each plot at harvest time to determin number of spikes/plant, spikes weight “g/plant”, main spike length “cm”, grain index (1000 grains in “g”), grain, straw and biological yield “g/plant”. In addition, grain, straw and biological yields (Ton/fed.) were calculated for the plot area and then converted to yield per feddan, where migration coefficient, crop index and harvest index were determined according to Abdel-Gawad *et al.* (1987). Relative photosynthetic potential (RPP) for biological and grain yields and vegetative organs were calculated according to the method described by Vidovic and Pokorny (1973).

Chemical Analysis:

Photosynthetic pigments (Chlorophyll a, chlorophyll b and carotenoids) in the leaves at 45 days from sowing were determined as the method described by Moran (1982). Also, in the same plant age, endogenous hormones, namely indole acetic acid (IAA, gibberelic acid (GA_3), abscisic acid (ABA) and cytokinins (as zeatin and zeatin riboside) were exracted according to Wasfy and Orrin (1975). IAA, GA_3, ABA were determined by Gas Liquid Chromatography (GLC) according to the method described by Wasfy and Orrin (1975) and cyokinin was determined by High Performance Liquid Chromatography (HPLC) according to the method described by Muller and Hilgenberg (1986). The method used for extraction and determination of total carbohydrate in the grain and staw was similar to that described by Smith *et al.* (1956), meanwhile total nitrogen (%) was determined according to AOCS (1984) and was multiplied by 6.25 to calculate protein (%).

Statistical Analysis:

The data obtained were subjected to analysis of variance (ANOVA). Since the trend of the results was similar in both seasons, the combined analysis of the data was carried out **(Gomez and Gomez, 1984)**. Treatment means were compared using the least significant differences test (LSD) at the 0.05 level

Results and Discussion

A- Growth characters:-

A-1: Cultivars differences:-

The results illustrated in Table (1) showed significant differences among three barely cultivars under this study, i.e. Giza-129, Giza-130 and Giza-131 in growth characters, i.e. plant height, number of tillers, active leaves and spikes/plant, dry wt. of tillers + sheats, blades and spikes/plant, flag leaf area, blades area/plant and LAI at 80, 95 and 110 days after sowing. Moreover, plant height, number of spikes, spikes dry wt./plant and flag leaf blade area tended to increase with advance plant age up to 110 days after sowing, whereas, number of tillers and active leaves/plant, tillers + sheats and blade dry weight/plant, blades area/plant and LAI tended to increase with advance of plant age up to 95 days after sowing and thereafter decreased. It is worthy to mention, that Giza-131 cultivar gave the highest significant values from growth characters studied compared with the other two cultivars Giza-130 and Giza-129, respectively.

It is worthy that the cultivar differences in growth characters are in hormany with results obtained by Abd-Alla (2004), Abd El-Hameed and Ash-Shormilleys (2005), Alberta (2007), Sharbanek *et al.* (2008), Hussein *et al.* (2009) and Ahmed *et al.* (2013). Furthermore, cultivar differences in growth characters in this study may be due to the differences in genetic structure, and to the widely cultivar differences between genotypes for mineral elements concentrations (Clarc *et al.*, 2007). Also, the decreament in dry weight of tillers + sheats and blades area/plant in constant with the increase in spikes dry weight/plant with advancing plant age after 95 days from sowing may be due to the migration of photosynthates from tillers + sheats and blades (Source) to grains per spike (Sink) and again to the cultivar differences in photosynthat partitioning (Ahmed *et al.*, 2013).

A-2: Salicylic acid concentraions (SA):-

Data presented in Table (1) show that soaking barely seeds with different concentrations of salicylic acid caused significant increases in growth characters of barely plant at 80, 95 and 110 days after sowing. The most effective concentration was 100 mg/l for plant height, number of tillers; blades and spikes/plant, dry weight of tillers + sheats, blades and spikes/plant, flag leaf blade area, blade area/plant and LA compared with the other four concentrations, 75, 50, 25 and 0.0 mg/l, respectively. Again, plant height, number of spikes/plant, spikes dry wt./plant, and flag leaf blade area tended to increase with advance plant age up to 110 day after sowing, meanwhile, number of tillers and active leaves/plant, dry weight of tillers + sheats and blades, blades area/plant and LAI tended to increase with advance plant age up to 95 days after sowing and thereafter decreased. Our results are in agreement with those reported by El-Khallal *et al.* (2009) and Delavare *et al.* (2010) on different plant species. The promotive effect of SA could be attributed to its bioregulator effects on physiological and biochemical processes in plants such as ion uptake, cell elongation, cell division, cell differentiation, sink and source regulation, enzematic activities, protein synthesis and photosynthetic activity; as well as; increase the antioxidant capacity of plant (Raskin, 1982, Blokhina *et al.*, 2003 and El-Tayeb, 2005). Salicylic acid as anti-stress substance may enhanced the plant tolerance to environmental stresses (Sreenivasulu *et al.*, 2000). The promoting effect of SA on the flag leaf blade area and blades are/plant and LAI mentioned that enhancing effect of SA on the availability and movement of nutrients could result in stimulating different nutrients in the leaves.

A-3: Effect of the interaction:-

Table (1) show that the interaction between barely cultivars and different concentrations of salicylic acid caused significant effects on plant height, number of tillers; blades and spikes/plant, dry weight of tillers + sheats, blades and spikes/plant, flag leaf blade area, blades area/plant and LAI at the different plant ages of barley plant. Data show also that the most effective treatments for growth characters values was Giza-131 cultivars under soaking its seeds with 100 mg/l SA. In addition, plant height, number of spikes/plant, spikes dry wt./plant and flag leaf blade area tended to increase with advance plant age up to 110 days after sowing, however, number of tillers and active leaves/plant, tillers + sheats and blades dry wt./plant, blades area/plant and LAI tended to increase with advance age of plant up to 95 days and thereafter declined.

B- Photosynthetic pigments content:-

B-1: Cultivar differences:-

Regarding the influence of cultivar differences (Table 2), the results revealed significant differences Giza-129, Giza-130 and Giza-131 cultivars in Chl. a, Chl. b and carotenoids. Giza-131 cultivar significantly exceeded other cultivars Giza-129 and Giza-131 in photosynthetic pigments content. This differences may be due to the differences in genetic structure, and to the widely cultivar differences between genotypes for mineral element with those obtained by (Kandil *et al.*, 2001).

B-2: Effect of salicylic acid concentratios:-

Data presented in Table (2) observed that soaking barley seeds with different concentrations of SA caused significant increases in photosynthetic pigments (Chl. a, Chl. b and carotenoids and consequently total photosynthetic pigments content) when combared with untreated plants (control treatment). The effective concentration was 100 mg/l SA where this treatment was the most pronounced treatment in increasing Chl. a, Chl. b and carotenoids then consequently total photosynthetic pigments content. These results are corroborated with those of Khodary (2004) on maize, El-Tayeb (2005) and Gunes *et al.* (2005) on maize. The enhancing effects of SA on photosynthetic capacity could be attributed to its stimulatory effect on Rubisco activity and pigment contents (Khadary, 2004), as well as, increased CO_2 assimilation, photosynthetic rate and increased mineral uptake by the plant (Szepesi *et al.*, 2005). Moreover, salicylic acid act as one of antioxidant substances concentrated in the chloroplast and protect the photosynthetic apparatus when a plant is subjected to stress, by scavenging the excessively reactive oxgen spices known as free radicals. Such effects might be due to protecting the endogenous antioxidant systems often correlated with increased resistance to oxidative stress and/or controlling the level of free radicals within plant tissues (Sreenivasulu *et al.*, 2000).

B-3: Effect of interaction:-

Data reported in Table (2) indicate that the effect of the interaction between barley cultivars and different concentrations of salicylic acid was significant on photosynthetic pigments contents in barley plants. Generally, the most effective treatment for photosynthetic pigments content was Giza-131 under soaking with 100 mg/l SA.

C- Endogenous hormones content:-

C-1: Cultivar differences:-

With respect of endogenous hormones content; Table (2) show clearly that the barley cultivars Giza-129, Giza-130and Giza-131 different in its content from IAA, ABA GA_3 and cytokinins. Moreover, Giza-131 cultivar characterized by its highest content from the endogenous plant growth promotores IAA, GA_3 and cytokinins compared with Giza-130 and Giza-129, respectively. On the contrary, Giza-129 had the highest value from the endogenous growth inhibitor ABA compared with Giza-131 and Giza-130 cultivars. The differences in endogenous hormones content may be due to the differences in genetic structure.

C-2: Effect of salicylic acid concentrations:-

Table (2) show that SA marked increament in IAA, GA_3 and cytokinins, in the meantime decrease in ABA content comparing with untreated controls. The most effective treatment for increasing endogenous plant growth promoters IAA and GA_3 and cytokinins and decreasing endogenous plant growth inhibitors ABA was 100 mg/l SA compared with 0, 25, 50 and 75 mg/l SA, respectively. Our results are in good agreement with those obtained by Shehata *et al.* (2000), Shehata *et al.* (2001), and Zaghlool (2002). The increases in IAA and GA_3 in shoot tissues of barley plant concurrently with the increase in growth rate due to the role of these endogenous hormones in stimulating cell division and/or the cell enlargement and subsequently growth (Taiz and Zeiger, 1998). It is well known that SA induces flowering, increase flower life, retard senescence and increase cell metabolic rate. Also, SA may be a prerequisite for synthesis of auxin and/or cytokinin (Metwally *et al.*, 2003 and Gharib, 2006). In addition, these increaments in growth regulating substances might be a prerequisite for acceleraction of growth resumption of barley plant. Furthermore, SA effects on ABA (Senaranta *et al.*, 2000), GA_3 Traw and Bergelson (2003) regulate many physiological processes and plant growth. Such increases in the levels of endogenous growth promoters could be attributed to the increase in their biosynthesis and/or decrease in their degradation and conjugation. On the other hand, the decreament in ABA content attributed to the shift of the common precursor isopentenyl pyrophosphate to biosynthesis of cytokinins and/or gibberellins instead of ABA (Hopkins and Huner, 2004).

C-3: Effect of interaction:-

Table (2) show the effect of the interaction between barley cultivars and SA concentration. The most effective treatment for collecting the highest mean values from IAA, GA_3 and cytokinins in the meantime low values from ABA content are soaking Giza-131 barley seeds with 100 mg/l BA compared with other fourteen treatments under study.

D- Yield and its components:-

D-1: Cultivar differences:-

Table (3) indicates that significant differences were obtained on all studied traits except the different between the three barley cultivars, i.e. Giza-129, Giza-130 and Giza-131 in crop index and harvest index, where these two traits did not significantly differences. In all cases, Giza-131 cultivar significantly surpassed Giza-129 and Giza-130 in number of spikes/plant, spikes dry weight/plant, main spikes length, number of spikelets/spike, number of grains/main spikes, grain, straw and biological yield per plant and/or fed. and migration coefficient. Meanwhile, Giza-129 had the greatest mean values of RPP_{gr}, RPP_{bio}, RPP_{veg} compared with Giza-130 and Giza-131 cultivars. In addition Table (2) observed that Giza-131 cultivars significantly outweighed Giza-129 and Giza-130 cultivars in percentages of total carbohydrate and protein per grains and per straw, respectively. Moreover, cultivar differences in yield and yield components may be due to the differences in genetic structure and to the widely cultivar differences between genotypes for mineral elements concentration (Clarck *et al.*, 1997). Again, to cultivar differences in growth parameters (Table 1) and also to the cultivar differences in photosynthetic partitioning that previously indicated by Abdel-Gawad *et al.* (1987) and Ahmed (2013). Futhermore, the significant superiority of Giza-131 over Giza-129 and Giza-131 cultivar under study in number of spikes/plant, spikes weight/plant, main spike length, number of spikelets/spike, and number of grains/main spike, grain yield/plant and /fed. may be due to the high yielding cultivar had a more vigorous system for generating reduction potentials during plant growth than did the less productive cultivar and the higher yielding has a higher photosynthetic electron transport chain potential, which is a genetically character more than lower yielding cultivar (Abdel-Gawad *et al.*, 1987 and Ahmed *et al.*, 2013). In additions, the greater number of grains/main spike may explain its higher yield as such spikes are more effective sink for the carbohydrate synthesized in the leaves which fewer and larger grains (Ahmed, 2013).

Table 1: Effect of barley cultivars and salicylic acid concentration on growth parameters of barley plants (data are means of two seasons).

Cultivars	Salicylic acid conc. mg/l	Plant height "cm"			No. of tillers/plant			No. of active leaves/plant			No. of spikes/plant			Tillers + sheats dry wt. g/plant			Blades dry wt. g/plant			Spikes dry wt. g/plant			Flag leaf blade area cm²			Blades area cm²/plant			LAI		
		80	95	110	80	95	110	80	95	110	80	95	110	80	85	110	80	95	110	80	95	110	80	95	110	80	95	110	80	95	110
Giza-129		83.8	89.15	88.54	4.14	4.35	4.12	26.00	28.08	21.82	--	4.10	3.97	8.03	8.56	8.33	3.67	3.75	3.44	--	9.13	11.55	--	16.96	21.21	465.7	532.90	475.99	3.10	3.55	3.17
Giza-130		88.12	94.01	98.31	4.39	4.56	4.20	27.43	29.17	23.28	--	4.40	4.09	8.32	8.65	8.48	3.71	3.81	3.51	--	9.94	13.62	--	18.02	22.54	482.29	553.83	497.05	3.22	3.69	3.31
Giza-131		92.34	97.98	102.8	4.40	4.71	4.33	28.23	30.53	24.18	--	4.56	4.22	8.43	8.83	8.64	3.76	3.86	3.53	--	10.26	13.95	--	18.66	23.30	495.17	573.45	515.76	3.30	3.82	3.44
L.S.D. at 5% Level		3.30	2.50	1.23	0.01	0.13	0.12	0.33	0.44	0.26	--	0.09	0.05	0.08	0.14	0.10	0.03	0.04	0.01	--	0.22	0.18	--	0.23	0.17	6.76	8.12	14.30	0.07	0.11	0.09
	0	82.0	88.59	91.17	4.02	4.28	4.02	24.55	26.93	19.64	--	3.94	3.84	7.85	8.33	7.99	3.26	3.48	3.27	--	8.53	11.11	--	14.45	19.14	411.59	506.35	471.67	2.74	3.38	3.14
	25	84.97	90.07	94.33	4.15	4.45	4.11	25.97	28.67	20.93	--	4.30	3.97	8.08	8.46	8.34	3.69	3.72	3.46	--	9.25	12.76	--	15.50	20.89	472.03	542.75	483.87	3.15	3.62	3.23
	50	88.10	92.07	95.88	4.33	4.59	4.23	28.03	29.89	24.56	--	4.39	4.12	8.26	8.67	8.49	3.77	3.84	3.52	--	9.85	13.31	--	17.06	22.48	486.51	555.94	494.23	3.24	3.71	3.29
	75	92.07	94.90	99.78	4.50	4.66	4.29	28.67	30.33	25.11	--	4.50	4.22	8.45	8.86	8.67	3.90	3.97	3.60	--	10.46	13.88	--	20.3	24.07	510.5	575.29	509.77	3.40	3.84	3.40
	100	93.29	102.07	104.93	4.68	4.73	4.43	29.22	30.47	25.22	--	4.64	4.32	8.66	9.07	8.92	3.93	4.02	3.64	--	10.78	14.13	--	22.09	25.14	524.3	586.63	521.8	3.50	3.91	3.48
L.S.D. at 5% Level		1.05	0.41	0.46	0.16	0.04	0.11	0.36	0.12	0.09	--	0.13	0.08	0.14	0.10	0.21	0.02	0.4	0.03	--	0.19	0.17	--	0.56	0.67	11.30	4.95	7.41	0.09	0.05	0.07
Giza-129	0	77.5	84.33	85.6	3.70	4.00	3.88	23.3	25.8	18.2	--	3.5	3.67	7.59	8.21	7.77	3.18	3.36	3.20	--	7.87	10.65	--	13.50	17.63	396.18	497.0	455.01	2.64	3.31	3.03
	25	80.5	86.0	88.77	4.00	4.17	3.99	24.58	27.5	19.4	--	4.0	3.80	7.86	8.33	8.19	3.60	3.62	3.40	--	8.50	11.24	--	14.62	19.55	460.0	516.58	460.5	3.07	3.44	3.07
	50	85.7	89.6	90.50	4.17	4.48	4.18	26.8	28.67	23.11	--	4.17	4.00	7.99	8.58	8.37	3.75	3.84	3.49	--	9.31	11.72	--	16.07	21.68	468.0	520.6	472.68	3.12	3.47	3.15
	75	86.9	92.0	92.33	4.33	4.5	4.25	27.33	29.0	24.0	--	4.33	4.17	8.20	8.74	8.60	3.86	3.93	3.53	--	9.76	11.98	--	19.50	23.17	493.6	556.11	491.50	3.29	3.71	3.28
	100	88.4	93.8	95.50	4.50	4.60	4.30	28.0	29.43	24.33	--	4.50	4.20	8.50	8.94	8.72	3.95	3.99	3.61	--	10.19	12.15	--	21.13	24.0	510.72	574.2	500.26	3.40	3.83	3.34
Giza-130	0	82.5	87.55	92.40	4.17	4.33	4.00	24.17	27.0	19.33	--	4.00	3.85	7.90	8.28	8.05	3.26	3.48	3.27	--	8.60	11.24	--	14.77	19.8	412.6	507.65	473.0	2.75	3.38	3.15
	25	84.7	90.0	96.0	4.25	4.5	4.17	26.0	28.5	21.4	--	4.33	4.0	8.16	8.47	8.36	3.73	3.75	3.48	--	9.40	13.29	--	15.88	21.12	474.5	545.0	491.12	3.16	3.63	3.27
	50	87.6	92.4	97.15	4.33	4.60	4.20	28.3	30.0	25.0	--	4.5	4.17	8.38	8.65	8.49	3.76	3.84	3.52	--	10.11	14.00	--	17.30	22.61	491.14	551.63	497.0	3.27	3.68	3.31
	75	92.3	94.71	99.00	4.50	4.67	4.30	29.0	30.33	25.33	--	4.5	4.20	8.50	8.86	8.64	3.91	3.97	3.62	--	10.63	14.58	--	20.0	24.05	508.19	579.15	500.0	3.39	3.86	3.33
	100	93.48	105.4	107.0	4.70	4.7	4.33	29.67	30.0	25.33	--	4.67	4.25	8.65	8.98	8.87	3.91	4.00	3.64	--	10.94	14.97	--	22.14	25.10	524.0	585.7	524.14	3.49	3.90	3.49
Giza-131	0	86.0	93.9	95.5	4.18	4.50	4.17	26.17	28.0	21.4	--	4.33	4.00	8.05	8.50	8.16	3.34	3.59	3.33	--	9.13	11.45	--	15.08	20.0	426.0	514.4	487.0	2.84	3.43	3.25
	25	89.7	94.2	98.22	4.29	4.67	4.17	27.33	30.0	22.0	--	4.58	4.10	8.22	8.59	8.48	3.75	3.80	3.50	--	9.86	13.74	--	16.0	22.0	481.6	566.66	500.0	3.21	3.78	3.33
	50	91.0	96.8	100.0	4.50	4.70	4.30	29.0	31.0	25.5	--	4.50	4.20	8.41	8.78	8.62	3.84	3.85	3.54	--	10.13	14.21	--	17.8	23.15	500.38	595.6	513.0	3.34	3.97	3.42
	75	97.0	98.0	108.0	4.67	4.80	4.33	29.67	31.67	26.0	--	4.67	4.30	8.64	8.99	8.78	3.92	4.00	3.64	--	10.98	15.09	--	21.4	25.0	529.7	590.6	537.8	3.53	3.94	3.59
	100	98.0	107.0	112.28	4.85	4.90	4.67	30.0	31.97	26.0	--	4.74	4.50	8.83	9.28	9.17	3.93	4.07	3.66	--	11.22	15.26	--	23.0	26.33	538.18	600.0	541.0	3.59	4.00	3.61
L.S.D. at 5% Level		2.09	0.81	0.92	0.32	0.08	0.22	0.72	0.24	0.18	--	0.26	0.16	0.28	0.20	0.42	0.04	0.08	0.06	--	0.38	0.34	--	1.12	1.34	22.60	9.90	14.82	0.18	0.10	0.14

D-2: Effect of salicylic acid concentrations:-

Data in table (3) show the charges in yield and yield components of barley plants treated with different concentrations of salicylic acid grown under newly reclaimed sandy soil. The results shows significant variation between the five treatments of SA, i.e. 0.0, 25, 50, 75 and 75 mg/l. Data also show that soaking seeds of barely plants with different concentration of SA caused significant increases in yield and yield components (except crop index, harvest index and migration coefficient) compared to untreated plants. The most effective salicylic acid concentration was 100 mg/l SA for number of spikes/plant, spikes weight/plant, main spike length, number of spikelts/spike, number of grains/main spike, and grain, straw and biological yield per plant and or /fed. and harvest index, whereas, 75 mg/l SA had the highest RPP_{gr} and soaking barley seeds with 50 mg/l SA gave the greatest mean values from RPP_{bio} and RPP_{veg}. Moreover, Table (2) indicate that 100 mg/l SA treatment

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characterized with the highest content of grains and straw from total carbohydrate and protein percentages. Generally results of El-Khallal *et al.* (2009) and Delavari *et al.* (2010) confirmed with our results.

The promotive effect of SA could be attributed to its bioregulator effect on physiological and biochemical in plants such as ion uptake, cell elongation, cell division, cell differentiation, sink and source regulation, enzematic activities, protein synthesis and photosynthetic activity, as well as, increase in antioxidant capacity of plant (Paskin, 1992, Blokhina *et al.*, 2003 and El-Tayeb, 2005). Salicylic acid as anti-stress substance may enhance the plant tolerance to environmental stresses (Sreenivasulu *et al.*, 2000). The promoting effect of SA on the flag leaf blade area and blades area/plant and LAI (Table 1) mentioned that enhancing effect of SA on the availability and movement of nutrients could result in stimulating different nutrients in the leaves and consequently promote yield and yield components.

Table 2: Effect of barley cultivars and salicylic acid concentration and their interactions on chemical constituents of barley plants (data are means of two seasons).

Cultivars	Salicylic acid conc. mg/l	Photosynthetic pigment content (mg/g dry wt. of leaves)			Endogenous hormone content (per 100 g fresh wt.)				Total carbohydrate % per dry grain	Total carbohydrate % per straw	Crude protein % per dry grain	Crude protein % per straw
		Chl. a	Cha. B	Carotenoids	IAA (µg)	ABA (µg)	GA_3 (mg)	Cytokinins (µg)				
Giza-129		3.08	1.16	1.56	276.80	75.37	318.86	68.52	73.14	73.78	10.64	9.98
Giza-130		3.59	1.38	1.69	284.88	73.47	328.91	65.41	73.29	73.87	40.78	10.06
Giza-131		3.77	1.56	1.89	339.38	67.99	339.25	62.37	73.45	73.98	10.93	10.12
L.S.D. at 5% Level		0.08	0.12	0.09	---	---	---	---	0.11	0.10	0.09	0.02
	0	2.35	1.24	1.53	215.70	95.03	271.25	79.38	72.74	73.33	10.28	9.82
	25	3.16	1.26	1.60	263.90	79.21	286.96	70.75	72.93	73.84	10.51	9.89
	50	3.50	1.33	1.69	290.80	69.64	334.77	65.65	73.14	73.90	10.65	9.96
	75	3.83	1.47	1.82	315.46	60.48	362.27	62.08	73.49	74.04	11.00	10.16
	100	3.89	1.53	1.93	339.38	57.00	389.77	49.32	74.16	74.27	11.48	10.44
L.S.D. at 5% Level		0.05	0.03	0.06	---	---	---	---	0.38	0.13	0.15	0.09
Giza-129	0	2.60	0.96	1.43	205.00	99.37	258.75	81.7	72.42	73.28	10.19	9.75
	25	2.67	0.98	1.46	257.13	82.45	271.18	71.28	72.79	73.72	10.24	9.76
	50	2.87	1.07	1.50	277.5	73.19	329.1	69.5	73.06	73.84	10.57	9.88
	75	2.60	1.34	1.65	308.13	62.45	358.25	66.13	73.40	73.92	10.84	10.14
	100	3.65	1.43	1.77	336.25	59.37	375.0	54.0	74.03	74.14	11.35	10.38
Giza-130	0	3.07	1.31	1.55	216.33	97.12	273.25	79.2	72.80	73.29	10.28	9.82
	25	3.29	1.34	1.57	265.12	80.22	28130	73.24	72.84	73.87	10.55	9.93
	50	3.73	1.37	1.70	290.54	71.44	337.33	64.37	73.11	73.91	10.62	9.96
	75	3.91	1.42	1.77	312.58	60.19	361.25	61.5	73.49	74.03	10.99	10.15
	100	3.97	1.46	1.87	339.85	58.36	391.42	48.75	74.22	74.25	11.48	10.46
Giza-131	0	3.38	1.44	1.61	225.76	88.61	281.75	77.24	73.01	73.42	10.37	9.88
	25	3.52	1.47	1.77	269.44	74.97	306.41	67.13	73.15	73.94	10.73	9.99
	50	3.89	1.55	1.88	304.35	64.28	337.88	63.08	73.26	73.96	10.77	10.04
	75	3.98	1.64	2.05	325.66	58.79	367.32	58.6	73.58	74.17	11.18	10.20
	100	4.06	1.69	2.14	342.04	53.28	402.90	45.21	74.23	74.42	11.62	10.47
L.S.D. at 5% Level		0.10	0.06	0.12	---	---	---	---	0.76	0.26	0.30	0.18

Table 3: Effect of barley cultivars and salicylic acid concentration on yield and its components of barley plants (data are means of two seasons).

Cultivars	Salicylic acid conc. mg/l	No. of spikes /plant	Spikes wt. "g/plant"	Main spike length	No. of spikelets /spike	No. of grains / main spike	Grain yield "g/plant"	Straw Yield "g/plant"	Bio-yield "g/plant"	Grain yield "ton/fed."	Straw yield "ton/fed."	Bio-yield "ton/fed."	Crop index	Harvest index	RPP_{v} "g/LAI"	RPP_{bio} "g/LAI"	RPP_{yld} "g/LAI"	Migration coefficient
Giza-129		3.89	26.71	11.27	51.6	39.06	18.83	28.66	47.49	1.878	2.451	4.329	0.43	0.77	5.93	14.96	9.03	0.56
Giza-130		4.08	27.26	11.26	53.0	40.38	19.41	29.42	48.83	1.936	2.507	4.443	0.44	0.77	5.86	14.73	8.87	0.56
Giza-131		4.12	28.23	11.86	53.20	41.26	19.72	32.22	51.94	2.02	2.613	4.633	0.44	0.77	5.73	14.52	8.79	0.57
L.S.D. at 5% Level		0.02	0.43	0.12	0.09	0.48	0.17	0.99	1.26	0.041	0.085	0.14	n.s	n.s	0.10	0.11	0.06	0.01
	0	3.77	26.35	10.80	51.30	38.20	18.10	27.98	46.08	1.782	2.399	4.181	0.43	0.74	5.76	14.46	8.70	0.57
	25	3.96	27.06	11.08	52.47	38.97	18.64	28.50	47.14	1.874	2.448	4.322	0.43	0.77	5.79	14.63	8.84	0.57
	50	4.10	27.46	11.64	52.67	40.03	19.21	29.80	49.01	1.947	2.517	4.464	0.44	0.77	5.84	14.89	9.05	0.56
	75	4.17	28.00	12.07	53.03	41.40	20.11	30.32	50.43	2.014	2.584	4.598	0.44	0.78	5.92	14.85	8.93	0.55
	100	4.32	28.28	12.39	53.46	42.57	20.54	30.56	51.10	2.106	2.673	4.779	0.44	0.79	5.90	14.69	8.79	0.55
L.S.D. at 5% Level		0.06	0.14	0.11	0.27	0.38	0.13	0.12	0.53	0.08	0.057	0.117	n.s	n.s	0.02	0.04	0.07	n.s
Giza-129	0	3.50	25.77	10.45	49.9	37.6	17.80	26.57	44.37	1.738	2.331	4.069	0.43	0.75	5.87	14.64	8.77	0.58
	25	3.80	26.52	10.66	51.6	38.3	18.35	27.08	45.43	1.806	2.386	4.192	0.43	0.76	5.98	14.80	8..82	0.58
	50	3.96	26.78	11.49	518	38.9	19.07	29.31	48.38	1.894	2.449	4.343	0.44	0.77	6.05	15.36	9.31	0.55
	75	4.00	27.06	11.77	52.3	40.0	19.13	29.94	49.37	1.905	2.527	4.432	0.43	0.75	5.92	15.05	9.13	0.55
	100	4.20	27.41	12.00	52.4	40.5	19.52	30.40	49.92	2.047	2.565	4.612	0.44	0.80	5.84	14.95	9.11	0.55
Giza-130	0	3.80	26.00	10.92	51.7	38.4	18.03	28.02	46.05	1.765	2.396	4.161	0.42	0.74	5.72	14.62	8.90	0.56
	25	4.00	26.85	11.28	52.7	39.0	18.64	28.51	47.15	1.857	2.453	4.310	0.43	0.76	5.70	14.42	8.72	0.57
	50	4.17	27.46	11.53	53.0	39.8	19.22	29.98	49.20	1.941	2.501	4.442	0.44	0.78	5.81	14.86	9.05	0.56
	75	4.20	27.91	12.07	53.6	41.5	20.13	30.18	50.38	2.013	2.538	4.551	0.44	0.79	6.07	15.13	9.06	0.55
	100	4.25	28.07	12.50	54.0	43.2	20.96	30.39	51.35	2.106	2.649	4.665	0.45	0.80	6.01	14.71	8.70	0.55
Giza-131	0	4.00	27.29	11.03	52.3	38.6	18.46	29.34	47.80	1.844	2.471	4.315	0.43	0.75	5.68	14.71	9.03	0.58
	25	4.10	27.82	11.29	53.1	39.6	18.94	29.91	48.85	1.958	2.504	4.462	0.44	0.78	5.69	14.67	8.98	0.57
	50	4.17	28.14	11.91	53.2	41.4	19.35	30.10	49.45	2.007	2.600	4.607	0.44	0.77	5.66	14.46	8.80	0.57
	75	4.30	29.03	12.38	53.4	42..7	20.70	30.85	51.55	2.124	2.687	4.811	0.44	0.79	5.77	14.36	8.59	0.56
	100	4.50	29.37	12.67	54.0	44.0	21.14	30.88	52.02	2.166	2.804	4.97	0.44	0.77	5.86	14.41	8.55	0.56
L.S.D. at 5% Level		0.12	0.28	0.22	0.54	0.76	0.26	0.24	1.06	0.16	0.114	0.234	n.s	0.01	0.04	0.08	0.14	n.s

D-3: Effect of interaction:-

Data illustrated in Table (3) show that the effect of the interaction between barley cultivars and SA concentration was significant expect on crop index and migration coefficient where the effect was not significant. The most effective treatment for harvesting the greatest values from number of spikes/plant, spikes weight/plant, main spike length, number of spikelets/spike, number of grains/main spike, grain, straw and biological yields/plant and RPP_{gr} (Table, 3) and total carbohydrate and protein % per grain and straw (Table 2) 100 mg/l SA for Giza-131 cultivar, meanwhile, treatment 75 mg/l SA had the highest harvest index, and untreated Giza-131 plant gave the greatest values from RPP_{bio} and RPP_{veg}.

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