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Physiological Role Of Salicylic Acid In Improving Performance, Yield And Some Biochemical Aspects Of Sunflower Plant Grown Under Newly Reclaimed Sandy Soil

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Abstract: Salicylic acid (SA) is an endogenous plant growth regulator, acting as non enzymatic antioxidant and has a regulatory effect on some physiological and biochemical processes. Therefore, this work was conducted during two successive summer seasons to evaluate the performance of two sunflower cultivars (Sakha 53 and Giza 102) to salicylic acid. The plants were grown at the experimental station of Agricultural Production and Research Station, National Research Centre, El Nubaria Province, El Behaira Governorate, Egypt. Sunflower seeds were soaked for 12 hours with different concentrations of SA (0, 25, 50, 75,100 mg/l) before sowing. It was noted that cultivation of Giza 102 performed well than Sakha 53 under sandy soil conditions. The obtained data revealed that, all treatments caused significant increases in growth parameters and photosynthetic pigments. The maximum increases in total pigments are 26.12% and 11.96% for Sakha 53 and Giza 102 cultivars at treatments 50 and 100 mg/l salicylic acid respectively. In addition, 75 and 100 mg/l salicylic acid were the most effective concentrations in increments of endogenous phytohormones i.e. IAA, GA_3, zeatin and zeatin riboside as well as the most effective treatments in decreasing ABA for Sakha 53 and Giza 102 respectively. Significant increases in total carbohydrate and phenolic contents were obtained in shoots due to all treatments. Seed yield and components were increased significantly at all SA treatments. Since, the highest increases in seed yield (ton/fed) were 26.76 and 35.00% for Sakha 53 and Giza 102 at 75 and 100 mg/l salicylic acid respectively. All treatments caused significant increases in oil and protein % relative to those of the control. Meanwhile, a marked decrease in total saturated fatty acids accompanied by an increase in total unsaturated fatty acids was observed in both cultivars. Thus, SA treatments had regulatory effect on growth, seed yield, total carbohydrate, phenolic content and the quality of the oil in favour of the increase of unsaturated fatty acids of sunflower plant grown under newly reclaimed sandy soil.

Key words: Endogenous hormones, fatty acids, *Helianthus annuus*, oil content, photosynthetic pigments, protein, salicylic acid, seed yield.

INTRODUCTION

In Egypt, there is a great shortage in edible oil due to limited cultivated area of oilseed crops and a rapid increase of population growth rate. The oilseed production can be increased by two means, either by horizontal expansion (cultivation in newly reclaimed land) or by vertical expansion (using antioxidant or growth regulators). The newly reclaimed soil is mostly exposed to a combination of environmental stress conditions including low water availability, saline water, saline soil, nutrient deprivation, temperature fluctuations and high irradiances. In this concern, great efforts must be paid to increase plant tolerance to such conditions via selecting tolerant genotypes and applying the optimum cultural practices and / or treating the seeds (before sowing) or plants (at different growth stages) with some growth regulating substances that play an important role in helping plants to overcome partially the unfavourable conditions and avoid their negative effects on yield quantity and quality.

The average production of sunflower in Egypt, in 2005 was 39 000 tons, whereas the consumption amounted to 376 000 tons in the same year (FAO, 2006). Sunflower has gained much attention in order to meet the increasing demand for vegetable oil, especially it could be cultivated in different types of soils and climate conditions in the newly reclaimed soils (Osman and Awed, 2010). Sunflower as an important oilseed crop ranks the forth next to soybean, palm oil and canola as a source of edible oil in the world (FAS.USDA, 2008).

Sunflower (*Helianthus annuus* L.) has a short duration crop (90-120 days), so it can be grown twice a year. Sunflower seed contains 25-48 % oil and 20-27 % protein. Sunflower oil is composed of monounsaturated (C18:1) and polyunsaturated (C18:2) fatty acids with low saturated fatty acids (C16:0 and C18:0).

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, inhibition of ethylene biosynthesis, transpiration and stress tolerance (Khan *et al.*, 2003 and Arfan *et al.*, 2007). Salicylic acid is a tool to increase plant tolerance against the adverse effect

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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 plants (Najafian *et al.*, 2009).

The present work aimed to study the physiological role of salicylic acid on the growth, yield and some biochemical aspects of two sunflower cultivars grown under newly reclaimed sandy soil.

MATERIALS AND METHODS

The present study was carried out at the experimental station of Agricultural Production and Research Station, National Research Centre, El Nubaria Province, El Behaira Governorate, Egypt during two successive summer seasons (2010 and 2011).

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%; pH 7.80; organic matter 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.

Seeds of two sunflower cultivars were obtained from Agricultural Research Centre, Giza, Egypt, namely Sakha-53 and Giza-102. The seeds of the two cultivars were soaked for 12 h with different concentrations 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 replications in rows 4 meter long, 0.60 meter apart and 6 ridges with total area (14.4 m^2). The cultivars were considered as a main plot and the concentrations of salicylic acid (SA) as the sub plots. Hill spacing was 20 cm within the row. Seeds were sown at 3-5 seeds in each hill. Irrigation took place immediately after sowing, then once every week intervals according to agronomic practices in the district. Thinning was carried out at 15 days after sowing to secure one plants per hill on one side of the ridge**.** 45 kg N/fed as ammonium sulphate (20.6% N) were added in three equal doses at sowing, after thinning and before pre-configured buds flowering. 50 kg potassium sulphates (48% K_2O)/fed was added after plant thinning.

Data Recorded:

At vegetative growth stage (after 45 days from sowing), five plants were randomly taken from each plot to determine shoot height, number of leaves/plant, leaves area/plant as well as fresh and dry weight of shoot /plant. Photosynthetic pigments and endogenous hormones were determined in fresh leaves and shoot tissues respectively. Whereas, carbohydrate and phenolic contents were determined in dry shoot.

At harvest, a random sample of five plants was taken from each plot to determine head diameter (cm), seeds weight/head (g) and 100-seeds weight (g). Plants on the middle four ridges in each plot were harvested and their heads were air dried and threshed to estimate seed yield/fed as well as oil, protein and fatty acid composition of the yielded seeds.

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). Total carbohydrates were determined in the dry shoots using the colorimetric method described by Herbert *et al*., (1971). The method used for extraction and determination of total soluble carbohydrates was similar to that described by Smith *et al.*, (1956). Polysaccharides were calculated by the difference between total carbohydrates and soluble carbohydrates. Total phenolic compounds were determined according to method described by Snell and Snell (1953). Endogenous hormones, namely indole acetic acid (IAA), gibberellic acid (GA_3), abscisic acid (ABA) and cytokinins (as zeatin and zeatin riboside) were extracted according to Wasfy and Orrin (1975). IAA, GA_3 and ABA were determined by Gas Liquid Chromatography (GLC) according to the method described Wasfy and Orrin (1975) and cytokinin was determined by High Performance Liquid Chromatography (HPLC) according to the method described by Muller and Hilgenberg, (1986). Protein content in the yielded meals was determined by Bradford (1976). The oil content of the seeds was determined according to the procedure reported by A.O.A.C. (1990). As the quality of the oil depends on the proportion of different fatty acids, their composition was determined quantitatively by Gas Liquid Chromatography according to the method described by Fedak and De La Roche (1977).

Statistical Analysis:

The obtained results were subjected to the statistical analysis by M-STAT-C statistical analysis program (MSTAT, 1988). Since the trend was similar in both seasons, Bartlett’s test and the combined analysis of the two growing seasons were applied. Means were compared using least significant difference test at 5% probability level.

Results

Growth Parameters:

Data in Table (1) show the changes in growth parameters of two sunflower cultivars treated with salicylic acid and grown under newly reclaimed sandy soil. The results show significant variations between the two cultivars (Sakha 53 and Giza 102) in most growth parameters (shoot height (cm); leaves number/plant; leaves area/plant (cm^2) and dry weight of shoot per plant (g)). It is clear that growth parameters of Giza 102 cv. were more pronounced than that of Sakha 53 cv. at all treatments. Data also show that, soaking seeds (two cultivars) with different concentrations of salicylic acid caused significant increases in most growth parameters compared to untreated plants. The most effective salicylic acid concentration was 75 mg/l for Sakha 53 and 100 mg/l for Giza 102 for all growth parameters.

Table 1: Effect of salicylic acid on growth parameters of two sunflower cultivars grown under newly reclaimed sandy soil after 45 days from sowing (data are means of two seasons).

Treatments	Shoot height (cm)		Leaves number/plant		Leaves area/plant (cm^2)		Shoot fresh weight/plant (g)		Shoot dry weight /plant (g)	
Salicylic acid (mg/l)	Sakha 53	Giza 102	Sakha 53	Giza 102	Sakha 53	Giza 102	Sakha 53	Giza 102	Sakha 53	Giza 102
0	25.17	27.83	10.25	12.42	70.97	85.17	5.88	6.59	0.67	0.75
25	29.24	30.00	12.00	14.33	78.07	99.36	6.82	7.06	0.78	0.91
50	30.00	32.50	12.32	16.42	80.12	113.55	7.76	7.53	0.81	1.06
75	33.50	33.38	13.50	16.33	92.26	120.32	8.76	8.79	0.89	1.11
100	31.33	33.50	12.59	17.00	79.42	127.75	7.29	9.28	0.83	1.21
LSD at 5%	1.46		1.19		6.04		1.97		0.09	

Photosynthetic Pigments:

Data presented in Table (2) show that soaking sunflower seeds (Sakha 53 and Giza 102 cultivars) with different concentrations of salicylic acid caused significant increases in photosynthetic pigments (chlorophyll a, chlorophyll b, carotenoids and consequently total pigments) when compared with untreated plants. In respect to chlorophyll a, the most effective concentration was 75 mg/l for the two cultivars, whereas 100 mg/l was the most pronounced treatment in increasing carotenoid contents. The maximum increase in chlorophyll b and total pigments resulted at treatment 50 mg/l for Sakha 53 and at treatment 100 mg/l for Giza 102. The maximum increase percentages were 19.25% and 8.32% in chlorophyll a; 66.24% and 52.51% in chlorophyll b; 16.07% and 39.13% in carotenoids and 26.13% and 11.96% in total pigments for Sakha 53 and Giza 102 cultivars respectively.

Table 2: Effect of salicylic acid on photosynthetic pigments (µg/g fresh weight) of two sunflower cultivars grown under newly reclaimed sandy soil after 45 days from sowing (data are means of two seasons).

Treatments	Chlorophyll a		Chlorophyll b		Carotenoids		Total pigments	
Salicylic acid (mg/l)	Sakha 53	Giza 102	Sakha 53	Giza 102	Sakha 53	Giza 102	Sakha 53	Giza 102
0	1262	1334	314	259	112	115	1638	1748
25	1369	1356	518	331	118	135	2005	1832
50	1425	1380	522	338	120	140	2066	1858
75	1505	1445	426	341	125	160	2056	1921
100	1306	1402	372	395	130	160	1808	1957
LSD at 5%	7.45		4.88		5.74		7.65	

Endogenous Phytohormones:

Figures (1&2) illustrate the effect of soaking sunflower seeds (Sakha 53 and Giza 102 cultivars) with different concentrations of salicylic acid on acidic hormones (IAA, GA_3 and ABA) and cytokinin (zeatin and zeatin riboside) in plant shoot. It is clear that, shoots of Giza 102 cv. were characterized by higher IAA, GA_3, zeatin and zeatin riboside and lower ABA levels than Sakha 53 cv. at all treatments. Salicylic acid treatments demonstrate promotive effect on acidic hormones (IAA and GA_3) and endogenous cytokinin (zeatin and zeatin riboside) as compared with control plants. On the other hand, abscisic acid obviously decreased by salicylic acid treatments. Moreover, data clearly show that 75 mg/l and 100 mg/l were the most effective concentrations in increments of IAA, GA_3, zeatin and zeatin riboside as well as the most effective treatments in decreasing ABA for Sakha 53 and Giza 102 respectively.

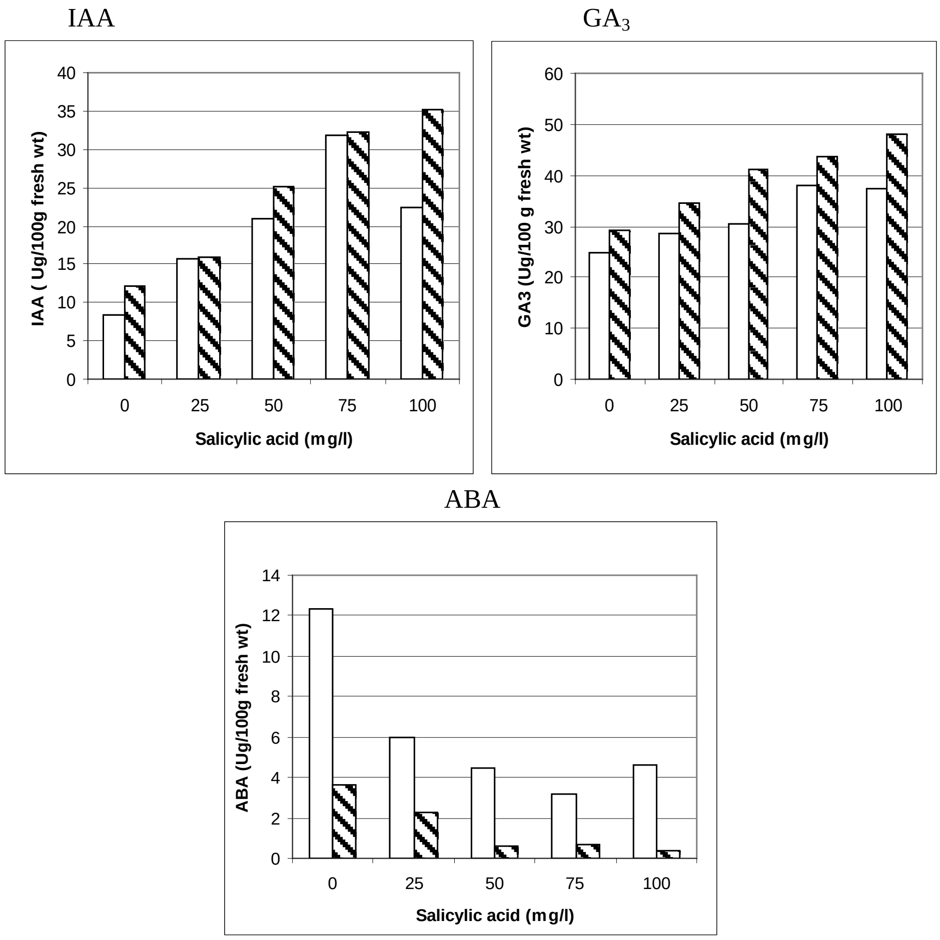

Fig. 1: Effect of salicylic acid on endogenous phytohormones, IAA, GA_3 and ABA (µg/100g fresh weight) in the shoot of two sunflower cultivars grown under newly reclaimed sandy soil after 45 days from sowing (clear vertical bar for Sakha 53 cultivar and vertical bar with diagonal lines for Giza 102 cultivar).

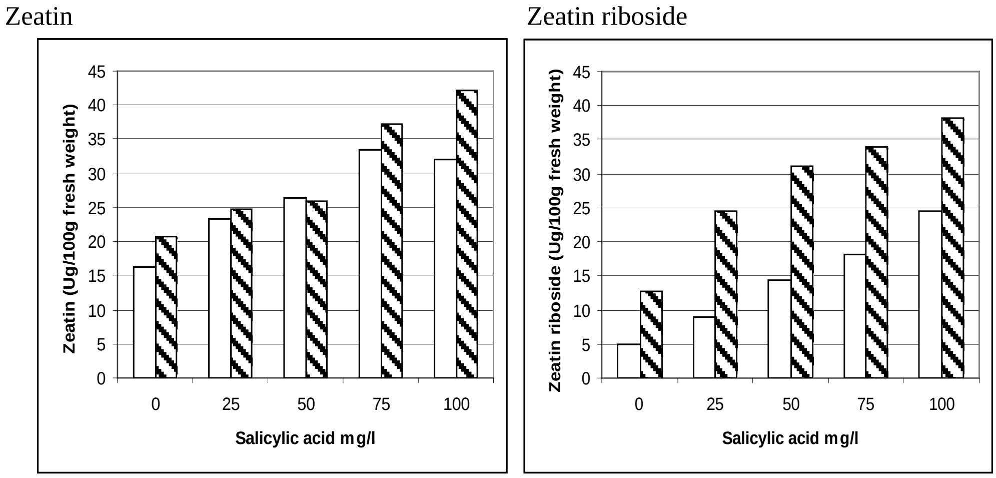

Fig. 2: Effect of salicylic acid on endogenous phytohormones (zeatin and zeatin riboside as µg/100g fresh weight) in the shoot of two sunflower cultivars grown under newly reclaimed sandy soil after 45 days from sowing (clear vertical bar for Sakha 53 cultivar and vertical bar with diagonal lines for Giza 102 cultivar).

Table 3: Effect of salicylic acid on carbohydrate (mg/100g dry weight) and phenolic contents (%) of two sunflower cultivars grown under newly reclaimed sandy soil after 45 days from sowing (data are means of two seasons).

Treatments	Total soluble carbohydrates		Polysaccharides		Total carbohydrates		Phenolic content	
Salicylic acid (mg/l)	Sakha 53	Giza 102	Sakha 53	Giza 102	Sakha 53	Giza 102	Sakha 53	Giza 102
0	2274	2803	13240	13177	15514	15980	0.291	0.300
25	2174	2694	13294	13557	15968	16251	0.382	0.341
50	2084	2475	14266	14512	16350	16987	0.394	0.347
75	2075	2457	14503	14597	16578	17054	0.395	0.372
100	2103	2326	14221	14943	16324	17269	0.384	0.358
LSD at 5%	72.36		174.36		175.36		0.030	

Carbohydrate and Phenolic Contents:

Soaking sunflower seeds with different concentrations of salicylic acid caused significant increases in total carbohydrate contents and polysaccharides accompanied by significant decrease in total soluble carbohydrates in sunflower shoot tissues as compared with control plants (Table, 3). It is obvious that total carbohydrate contents increased with increasing salicylic acid concentrations particularly at 75 and 100 mg/l for Sakha 53 and Giza 102 respectively. In addition, phenolic contents of sunflower shoots (Table, 3) significantly increased for both cultivars under the effect of all treatments and the highest significant increase was at treatment 75mg/l salicylic acid for both cultivars

Seed Yield and Yield Components:

Table (4) demonstrate that salicylic acid enhanced sunflower seed yield and yield components significantly, expressed as head diameter, 100 seeds weight and seeds weight/ head as compared with the untreated plants. Maximum increments were obtained by applying 75 and 100 mg/l of salicylic acid for Sakha 53 and Giza 102 respectively. The highest increments percentage were 16.16%, 31.85% for head diameter, 33.69% and 43.74% for 100 seeds weight, 42.32% and 46.25% for seeds weight /head and 26.76% and 35.00% for seeds yield (ton/fed) of Sakha 53 and Giza 102 respectively.

Regarding oil% and protein % of the yielded sunflower seeds, the data show that soaking sunflower seeds with different concentrations of salicylic acid increased significantly oil% and protein% (Table, 4). These increments parallel with increasing salicylic acid concentrations and the most effective treatments were 75 and 100 mg/l salicylic acid for Sakha 53 and Giza 102 respectively.

Table 4: Effect of salicylic acid on seed yield and yield components of two sunflower cultivars grown under newly reclaimed sandy soil (Data are means of two seasons).

Treatments	Head diameter (cm)		100 seeds weight(g)		Seed yield/head (g)		Seed yield (ton/fed)		Oil %		Protein %	
Salicylic acid (mg/l)	Sakha 53	Giza 102	Sakha 53	Giza 102	Sakha 53	Giza 102	Sakha 53	Giza 102	Sakha 53	Giza 102	Sakha 53	Giza 102
0	14.91	14.82	6.62	6.79	15.03	19.20	0.71	0.80	28.17	26.93	14.65	14.98
25	16.22	15.52	7.18	7.05	17.73	21.44	0.74	0.89	31.00	29.06	14.70	15.5
50	16.51	16.11	7.30	7.82	19.68	22.70	0.82	0.95	30.03	30.88	15.00	15.93
75	17.32	17.63	8.85	8.65	24.39	25.31	0.90	1.05	32.50	33.24	15.70	15.73
100	17.14	19.54	7.82	9.76	19.26	28.08	0.80	1.08	30.78	33.27	15.23	16.40
LSD at 5%	0.66		0.5		1.06		0.04		1.29		0.43	

Fatty Acid Composition:

The results of gas chromatographic analysis of the methyl esters of fatty acids of the yielded sunflower oil are shown in Table (5). The obtained data revealed that all treatments caused marked decrease in total saturated fatty acids (Ts) accompanied by an increase in total unsaturated fatty acids (Tu). Thus, ratio Tu/Ts also increased. Stearic (C18:0) and palmitic(C16:0) acids were predominant saturated fatty acids while, oleic acid(C18:1) was the major unsaturated fatty acid followed by linoleic acid (C18:2) in both cultivars.

Table 5: Effect of salicylic acid on fatty acid composition of two sunflower cultivars grown under newly reclaimed sandy soil

Fatty acids	Treatments									
	Salicylic acid (mg/l)									
	0		25		50		75		100	
	Sakha 53	Giza 102	Sakha 53	Giza 102	Sakha 53	Giza 102	Sakha 53	Giza 102	Sakha 53	Giza 102
16:0	9.84	8.70	9.99	8.72	9.52	8.28	6.33	7.44	4.40	6.44
18:0	7.54	7.99	6.14	6.47	3.11	6.10	3.83	4.66	4.88	4.52
20:0	1.22	1.12	0.94	1.06	1.79	0.97	1.68	0.99	1.61	0.67
16:1	0.82	1.02	0.75	0.80	0.61	0.86	-	0.70	0.29	0.52
18:1	41.63	52.17	42.45	47.33	45.29	46.05	47.33	49.96	57.94	49.42
18:2	35.42	26.85	35.13	33.33	38.14	34.67	37.85	31.98	29.18	34.58
18:3	0.78	0.57	0.98	0.57	0.90	0.70	1.00	0.54	0.62	1.07
20:1	0.24	0.09	0.49	0.32	0.42	0.39	0.60	0.44	0.24	0.61
Ts	18.60	17.81	17.07	16.25	12.42	15.35	11.84	13.09	10.89	11.63
Tu	78.89	80.70	79.80	82.65	84.46	82.67	86.78	83.62	88.27	86.20
Total	97.49	97.51	96.87	98.90	96.68	98.02	98.62	96.71	99.16	97.83
Tu/Ts	4.24	4.53	4.67	5.09	6.80	5.38	7.33	6.39	8.10	7.41

(Ts) Total saturated (Tu) Total unsaturated

Discussion:

The effect of salicylic acid on the physiological processes was stated to be variable, promoting some processes and inhibiting others depending on its concentration, plant species, developmental stages and environmental conditions (El-Mergawi and Abd El-Wahed, 2004). In addition, salicylic acid has a regulatory effect on activating biochemical pathways associated with tolerance mechanisms in plants (Najafian *et al*., 2009). Soaking seed with salicylic acid have been shown to enhance stand establishment in non saline areas (Khan, 1992) and have potential in saline areas as well (Basra *et al.,* 2005).

Soaking sunflower seeds with different concentrations of salicylic acid (Table, 1) caused significant increases in most growth parameters. These results are in agreement with those reported by Abd El-Wahed *et al*., (2006), El-Khallal *et al*., (2009) and Delavari *et al.,* (2010) on different plant species. The promotive effect of salicylic acid 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/source regulation, enzymatic activities, protein synthesis and photosynthetic activity as well as increase the antioxidant capacity of plants (Raskin, 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 leaf area was attributed to its important roles on activating cell division and the biosynthesis of organic foods. In addition, Raskin (1992) mentioned that enhancing effect of SA on the availability and movement of nutrients could result in stimulating different nutrients in the leaves.

Salicylic acid caused significant increases in photosynthetic pigments (Table, 2). These results corroborate with those of Khodary (2004) on maize, El-Tayeb (2005) on barley and Gunes *et al.*, (2005) on maize plant. The enhancing effects of SA on photosynthetic capacity could be attributed to its stimulatory effects on Rubisco activity and pigment contents (Khodary, 2004) as well as increased CO_2 assimilation, photosynthetic rate and increased mineral uptake by the plant (Szepesi *et al.,* 2005). Moreover, salicylic acid acts 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 oxygen species known as free radicals. Such effects might be due to protecting the endogenous anti-oxidant systems often correlated with increased resistance to oxidative stress and/or controlling the level of free radicals within plant tissues (Sreenivasulu *et al.,* 2000).

Photosynthetic pigments were increased in response to salicylic acid treatments (Table, 2) thus enhance biosynthesis of polysaccharides and total carbohydrates significantly (Table, 3) which are utilized in growth of sunflower plants. These results are in line with the findings of El - Tayeb and Ahmed (2010).

SA application might activate the metabolic consumption of soluble sugars to form new cell constituents as a mechanism to stimulate the growth of sunflower plants. Moreover, SA treatment might also be assumed to inhibit polysaccharide-hydrolyzing enzyme system on one hand and/or accelerate the incorporation of soluble sugars into polysaccharides. Our assumption could be supported by the result that SA increased polysaccharide level on the sake of soluble sugars and activate the consumption of soluble sugar metabolism by increasing osmotic pressure (Zahra *et al.,* 2010).

SA caused marked increments in IAA, GA_3, zeatin and zeatin riboside, in the meantime decrease in ABA content comparing with untreated controls (Fig. 1 and 2). These 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 sunflower 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 salicylic acid induces flowering, increases flower life, retard senescence and increases cell metabolic rate. In addition, salicylic acid may be a prerequisite for synthesis of auxin and /or cytokinin (Metwally *et al.,* 2003 and Gharib, 2006). Furthermore, these increments in growth regulating substances might be a prerequisite for acceleration of growth resumption of sunflower plant. In addition, salicylic acid effects on abscisic acid (Senaranta *et al.,* 2000), gibberellins (Traw and Bergelson, 2003) regulate many physiological process 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 decrease 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).

Concerning the stimulatory effect of salicylic acid on seed yield and yield components (Table, 4) may be attributed to the effect of salicylic acid on many biochemical and physiological processes that were reflected on improving vegetative growth and active translocation of the photosynthesis products from source to sink. The obtained results are in agreement with Abd El Wahed *et al.,* (2006) and El-Khallal *et al.,* 2009) on maize plant.

The increment in oil% and protein% might be due to the increase in vegetative growth and nutrients uptake. Similar results were reported by Gharib (2006) and Çag *et al.,* (2009). In addition, Noreen and Ashraf (2010) mentioned that high doses of salicylic acid caused marked increases in sunflower achene oil content as well as some key fatty acids and significant decrease in stearic acid. Moreover, the increase of cytokinins as shown in Fig. (2) may play a role in fatty acid synthesis as well as desaturation and chain elongation reaction and appeared to increase unsaturation fatty acid at the expense of saturated fatty acid in the yielded oils (Ibrahim *et al.,* 2001).

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