Plant Archives Vol. 20, Supplement 1, 2020 pp. 1563-1569 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

EVALUATION OF THE BIOLOGICAL RESPONSE OF THE SALICYLIC ACID ON GROWTH AND YIELD OF OAT

Rafid Kamel Odib and Ehsan Nawaf Dahal*

University of Baghdad - College of Agricultural Engineering Sciences - Field Crops Department, Iraq.

Abstract

A field experiment was conducted during the winter season 2018-2019 in the research station (A) of the Field Crop Sciences Department / College of Agricultural Engineering Sciences / University of Baghdad. The main aim of the study was to evaluate the biological response of salicylic acid in the growth and yield of oat (shifaa variety). The experiment was carried out using Randomized Complete Block Design, by split plot design arrangements with three replicates. The experiment included two factors, the first one was the growth stages in which salicylic acid was added in four growth stages including: beginning of tillering stage (Z 22) elongation stage (Z 30), then booting stage (Z 45) and the heading stage (Z 51), which represented the main plots. While the second factor consisted of a concentrations of salicylic acid 100, 200 and 300 ppm, as well as the comparison treatment. The results showed that beginning of tillering stage was significantly superior in most growth and yield traits, which were represented by plant height, number of tillers, flag leaf area. As well as, plant dry weight, number of grains in panicle, grain yield and the biological yield, and the rates of 121.77 cm, 573.75 tiller.m^{-2}, 61.87 cm^2, 1319.58 gm.m^{-2}, 52.25 grain.panicle^{-1}, 7.91 ton.h^{-1} and 24.39 ton.h^{-1} were achieved, respectively, compared to other growth stages. Finally, the results also showed that the concentration of 100 ppm was superior significantly in the above-mentioned traits and recorded a rate of 120.18 cm, 570.92 tiller.m^{-2}, 60.61 cm^2, 1310.00 g.m^{-2}, 51.51 grain.panicle^{-1}, 8.43 ton.h^{-1} and 24.91 ton.h^{-1}, respectively, compared with the comparison treatment and some of the other concentrations. As well as, the effect of the same concentration on the increasing the weight of 1000 grains. It can conclude from this study that the growth stage in which salicylic acid is added is one of the factors that determine the plant's response to salicylic acid, also can conclude that salicylic acid can be used to improve the plant's performance represented by plant growth and yield.

Key words : Biological Response, Salicylic Acid, Oat.

Introduction

Oat is one of the most important grain crops in the world, which is ranked the fourth among these crops. Oat grains are used in human food because they are rich in carbohydrates, protein, oil and fiber by (57.8%, 12.2%, 4.3% and 12.1%), respectively (Sterna *et al.,* 2015), and it is also used in animal feed through mowing the plants or grazing due to its ability and high speed in growth and branching. The area planted with oats in the world reached to 10.194,793 hectares, with a production rate of 25.949.161 ton, while the area planted in Iraq counted to 144 hectares and gave a production of 412 tons (FAO, 2017). Scientists and researchers are trying to experiment and discover new scientific methods and modern techniques in an attempt to increase the agricultural production, including the use of plant growth regulators, which are a chemical means to stimulate the plant to carry out its physiological functions, and are thus described as growth-altering substances and not nutrients. The salicylic acid, a newly discovered plant growth regulator of a phenolic nature, where it regulates a number of important physiological processes in plant growth and development, such as carbon representing, opening and closing stomata, urging the plant to flowering, absorbing ions. As well as, increasing enzymatic activity, delaying plant senescence and increasing meristematic cell division of root (Raskin, 1992; Hayat and Ahmed, 2007; Yusuf *et al.,* 2013; Khafaji, 2014). In addition, increasing plant susceptibility to endure non-vital environmental stresses such as drought (Roa *et al.,* 2012), salinity (Jini and Joseph 2017), heat (Kolupaev *et al.,* 2011), and biological stresses such as pathogens (EL-Mougy 2004), and insects (Park *et al.,* 2009). The plant's response to salicylic acid

***Author for correspondence :** E-mail : dr.ehsan_n_d@yahoo.com

depends on the growth stage in which it is added and the concentration used. Therefore, the optimal growth stage must be chosen to add the acid, as the plant goes through sequential growth stages at which the size of the shoot and root, number of tillers, number of spikes, number of grains and their size are determined. Thus, the addition of acid in a certain growth stage gives positive results compared to the addition in other growth stages (Hussein, 2015). Finally, this study was carried out with the aim of determining the best growth stage for the addition of salicylic acid and the optimum concentration and their effect on the growth and yield of oat.

Materials and Methods

A field experiment was conducted during the winter season 2018-2019 in the research station (A) of the Field Crop Sciences Department / College of Agricultural Engineering Sciences / University of Baghdad. The main aim of the study was to evaluate the biological response of salicylic acid in the growth and yield of oat grains, where the experiment was carried out using Randomized Complete Block Design (RCBD), by split plot design arrangements with three replicates. The experiment included two factors, the first one was the growth stages in which salicylic acid was added in four growth stages according to Zadoks scale: start of tillering stage (Z 22) and the elongation stage (Z 30), then booting stage (Z 45) and the heading stage (Z 51), which represented the main plots. While the second factor consisted of a concentrations of salicylic acid 100, 200 and 300 ppm, as well as the comparison treatment, which represented subplots. Salicylic acid concentrations used in the experiment were prepared in the laboratory of graduate studies of the College of Agricultural Engineering Sciences / University of Baghdad by adding 0.1, 0.2 and 0.3 g of salicylic acid powder to the distilled water and then completing the volume to the liter. The salicylic acid used in the study is a white powder whose chemical formula is $C_7H_6O_3$ with a low water solubility and its density is 1.443 $g.cm^{-3}$, boiling degree 484° and its PH is 2.4. Salicylic acid was sprayed at its four concentrations on the plants according to the growth stages mentioned above, the plants were sprayed till full wet, while the plants of comparison treatment were sprayed with distilled water only, and other materials have been used to reduce surface tension. The experiment land was divided after soil service operations, according to the recommendations on three replicates, each replicate consisted of 12 experimental units, where the area of the experimental unit was 4 m^2 with a dimension of 2m × 2m. The experimental unit contained 8 cultivation lines, and the distance between one line and another was 25 cm. Oat seeds were planted (shifaa variety) approved by the Ministry of Agriculture on 29/11/2018 with seeding rates of $120 kg.h^{-1}$. Finally, triple super phosphate fertilizer (P_2O_5 46%) was added at a rate of 100 $kg.h^{-1}$ at tillage stage, and the urea fertilizer at a rate of 110 kg $N.h^{-1}$ was added in four batches. The first batch at planting, the second at start of tillering stage and the third at start of elongation and the fourth at the flowering stage. Soil and crop service operations were carried out according to the recommendations, where the growth traits at flowering stage were measured approximately 100%, and the yield traits and its components were measured when plants reached full maturity on 3/5/2019. The significance was calculated by comparing the averages using the least significant difference (L.S.D) at a significant level 0.05 (Steel and Torrie, 1980). Furthermore, field soil samples were taken from different sites before starting the soil service operations randomly at a depth of 30 cm, and then collected together and one sample was taken for the purpose of measuring the physical and chemical properties of the soil as shown in (Table 1).

Table1: Some physical and chemical properties of the field soil.

Property		Unit	Value
PH value			7.5
Electrical Conductivity EC		$Ds.m^{-1}$	3.5
Organic matter OM		$g.k^{-1}$	0.61
Lime $CaCo_3$			34.1
Ca		$Meq.L^{-1}$	11.11
Cl			14.98
Available Nitrogen		Mg^{-1}	2.2
Available Phosphorus			4.98
Available Potassium			85.2
Soil separators	Clay	%	20.08
	Silt		30
	Sand		49.2
Soil texture			Loamy

Results and Discussion

Plant height (cm)

The variance analysis results showed that there was a significant difference between the growth stages in which salicylic acid was added in the plant height trait. As the growth stage of (Z 22) was significantly superior and achieved the highest average plant height of 121.77 cm compared to other growth stages, while the treatment of acid addition in the (Z 45) recorded the a lowest average for this trait was 115.24 cm as shown in (Table 2). This result was consistent with (Hussein 2015) findings, that there was an increasing in plant height when adding growth regulators, including salicylic acid at beginning of tillering stage. The addition of acid at an early stage allows the plant to benefit from one or more of physiological acid effects. The same table revealed that there is a significant difference in plant height to the effect of salicylic acid, the concentration of 100 ppm achieved the highest average plant height of 120.18 cm, which was not significantly different from the concentration of 200 ppm, and while the comparison treatment recorded the lowest average for this trait by 114.43 cm. This was consistent with (Azimi *et al.,* 2013) findings, which indicated that the external addition of salicylic acid increases the plant height. Moreover, spraying the plants with salicylic acid has positively effected in increase of its content from oxygen and gibberellin, which was reflected in an increase the plant height (Khan *et al.,* 2010). In addition, that spraying the plants with salicylic acid affects to increasing the division of meristematic tissue cells of root cells and thus increasing the absorption of water and what it contains of nutrients it, which positively reflects the increase of the plant's height (Hayat and Ahmed, 2007). As well as, a significant interaction between the growth stages in which the acid and concentrations were added, begining of tillering stage and a concentration of 100 ppm was superior by giving the highest average of the trait reached 129.23 cm compared to the lowest average of 112.77 cm at booting stage (Z 45) and for the same concentration.

Table 2: Effect of growth stages, salicylic acid concentrations, and their interaction on plant height (cm).

Salicylic acid concentrations	Growth stage				Average
	Z 22	Z30	Z45	Z51	
0	114.30	113.30	115.60	114.50	114.43
100	129.23	119.20	112.77	119.53	120.18
200	123.83	117.00	114.23	117.87	118.23
300	119.70	116.27	118.37	114.90	117.31
L.S.D 5 %	4.54				LSD 5%
Average	121.77	116.44	115.24	116.70	
L.S.D 5 %	4.09				2.27

Number of tillers (tiller.m^{-2})

The variance analysis results in table 3 results showed that there was a significant difference in the number of tillers by the effect of growth stages to add acid. As the (Z 22) stage was significantly superior and achieved the highest average amounted to 573.75 tiller.m^{-2} compared to the (Z 45) and (Z 51) stages only, while the growth stage (Z 51) recorded the lowest average of 553.25 tiller.m^{-2} which did not significantly different from the (Z 30) and (Z 45) stages. A similar finding was obtained by (Hussein and Al-baldawi 2015), which they pointed out that the external addition of growth regulators, including salicylic acid in begining of tillering stage has led to an increase in the number of tillers in wheat plants, where Salicylic acid positively affects the Cytokinins synthesis (Metually *et al.,* 2003). Since Cytokinins stimulate branching in plants, so the addition of salicylic acid in early stages, such as beginning of tillering stage (Z 22) provides enough time to make these changes before the final number of tillers is determined. It was observed from the two Tables mentioned above that salicylic acid had a significant effect on this trait, where the concentration of 100 ppm recorded the highest average by 570.92 tiller.m^{-2}, which was not significantly different from 200 ppm which recorded an average of 568.00 tiller.m^{-2}. However, it was significantly different from the concentration 300 ppm, which recorded an average of 561.50 tiller.m^{-2}, while the comparison treatment recorded the lowest average for this trait was 542.83 tiller.m^{-2}. This result was consistent with (Amin *et al.,* 2008) and findings, that salicylic acid increases the number of tillers in wheat plants. The increase in the number of tillers may be due to the role of salicylic acid in increasing the levels of some plant hormones, including Cytokinins that encourage branching process (Metually *et al.,* Ahmed 2007). In addition, the role of salicylic acid in increasing leaf content of chlorophyll, photosynthesis rate and the effectiveness of some important enzymes (Hayat and Ahmed, 2007), which positively effect on the branching process. There was also a significant interaction between the growth stages for acid addition and its concentrations, where the highest average at the (Z 22) stage and the concentration of 200 ppm has been 591.67 tiller.m^{-2}, while at the (Z 45) stage and for the same concentration were 557.67 tiller.m^{-2}.

Table 3: Effect of growth stages, salicylic acid concentrations, and their interaction on the number of tillers (tiller.m^{-2}).

Salicylic acid concentrations	Growth stage				Average
	Z 22	Z30	Z45	Z51	
0	540.33	546.00	539.67	545.33	542.83
100	588.67	570.67	568.33	556.00	570.92
200	591.67	564.67	557.67	558.00	568.00
300	574.33	566.67	551.33	553.67	561.50
L.S.D 5 %	15.82				LSD 5%
Average	573.75	562.00	554.25	553.25	
L.S.D 5 %	12.37				7.91

Flag leaf area (cm^2)

The variance analysis results in Table 4 showed that the growth stages in which salicylic acid was added, it positively and significantly effected in the flag leaf area. The (Z 22) stage was significantly superior and achieved the highest average of 61.87 cm^2, compared to other growth stages, followed by (Z 30) stage that significantly superior to an average of 59.28 cm^2. Afterward, the (Z45) stage with an average of 57.58 cm^2, which was not significantly different from the (Z 51) stage, which recorded the lowest average of 56.68 cm^2. A similar finding was obtained by (Hussein and Al-baldawi 2015) pointed out, that the addition of growth regulators, including salicylic acid in beginning of tillering stage has led to an increase in the flag leaf area. The same data indicate that salicylic acid was significantly effected in the flag leaf area, as the concentration of 100 ppm was superiority and recorded the highest average for this trait by 60.61 cm^2, which was not significantly different from the concentration of 200 ppm that recorded an average of 59.79 cm^2. Furthermore, the comparison treatment was recorded the lowest average of 57.43 cm^2, which in turn did not differ from the concentration of 300 ppm which recorded an average of 57.57 cm^2. This may be attributed to one or more physiological roles of salicylic acid in increasing the division of root cells, the absorption of water, and what it contains of nutrients and increases the chlorophyll content and photosynthesis efficacy, which reflected positively in increasing the flag leaf area (Hayat and Ahmed, 2007). A significant interaction between the growth stages and salicylic acid concentrations were also observed, as the highest average of interaction at the (Z 22) stage and the concentration of 100 ppm was 65.71 cm^2, while the same concentration at the (Z 51) stage gave an average of 57.14 cm^2.

Table 4: Effect of growth stages, salicylic acid concentrations and their interaction on flag leaf area (cm^2).

Salicylic acid concentrations	Growth stage				Average
	Z 22	Z30	Z45	Z51	
0	58.36	56.18	56.59	58.58	57.43
100	65.71	60.05	59.54	57.14	60.61
200	62.70	61.89	59.08	55.50	59.79
300	60.71	58.99	55.10	55.50	57.57
L.S.D 5 %	3.41				LSD 5%
Average	61.87	59.28	57.58	56.68	
L.S.D 5 %	1.64				1.71

Plant dry weight ($gm.m^{-2}$)

The variance analysis results in table 5 showed a significant effect of the growth stages on the plants dry weight. The (Z 22) stage was significantly superior with the highest average of this trait reached to 1319.58 $gm.m^{-2}$ compared to the other stages, followed by the (Z 30) stage was significantly superior with an average of 1262.41 $gm.m^{-2}$. Which did not differ significantly from the (Z 45) stage and the (Z 51) stage, while the (Z 45) stage recorded the lowest average of 1229.75 $gm.m^{-2}$, which in turn did not differ from the (Z 51) stage that recorded an average of 1232.00 $gm.m^{-2}$. The superiority of the (Z 22) stage in the plant height, number of tillers and the flag leaf area were reflected in its superiority on the plants dry weight as shown in Tables 2, 3 and 4. The same results indicate that salicylic acid had a significant with a positive effect on this trait. As the concentration of 100 ppm was significantly superior and achieved the highest average of 1310.00 $gm.m^{-2}$ compared to other concentrations, while the comparison treatment recorded the lowest average of 1227.08 $gm.m^{-2}$, which did not significantly differ from the concentration of 300 ppm that recorded an average of 1242.33 $gm.m^{-2}$. A similar finding was obtained by (Amin *et al.,* 2008) and, which they pointed out that there are an increase in dry weight of wheat plants with salicylic acid effect. This increase was explained by the fact that dry weight is a function of plant height, number of tillers, and flag leaf area, and these traits were positively affected by salicylic acid which reflected in increasing the dry weight as shown in Tables 2, 3, and 4. Finally, a significant interaction was observed in the growth stages and salicylic acid concentrations, the highest value of the interaction was for the (Z 22) stage and concentration 100 ppm compared to the (Z 45) stage and in the same concentration.

Table 5: Effect of growth stages, salicylic acid concentrations, and their interaction on plant dry weight ($g.m^{-2}$).

Salicylic acid concentrations	Growth stage				Average
	Z 22	Z30	Z45	Z51	
0	1234.67	1215.33	1216.00	1242.33	1227.08
100	1407.33	1327.67	1250.33	1254.67	1310.00
200	1354.00	1255.67	1231.00	1216.67	1264.33
300	1282.33	1251.00	1221.67	1214.33	1242.33
L.S.D 5 %	44.43				LSD 5%
Average	1319.58	1262.41	1229.75	1232.00	
L.S.D 5 %	35.76				22.21

Number of grains in panicle ($grain.panicle^{-1}$)

There was a significant difference in the number of grains in panicle by the effect of growth stages as indicated in the analysis of variance Table 6. The (Z 22) stage was significantly superior and achieved the highest average of 52.25 $grain.panicle^{-1}$, compared to other growth stages, followed by the (Z 30) stage was significantly superior with an average of 49.03 $grain.panicle^{-1}$, which did not differ significantly from the (Z45) that recorded an average of 47.84 $grain.panicle^{-1}$. While it was significantly different from the (Z 51) stage, which recorded an average of 47.45 $grain.panicle^{-1}$, which in turn did not differ significantly from the stage (Z 45). The flag leaf has an important role that contributes to the spike yield (number of grains and its weight) by 30.1-35.29%, especially in the early stages of its appearance. Therefore, the superiority of (Z 22) stage in the flag leaf area as shown in table 4 was reflected in its superiority on the number of grains in panicle. The results indicated that the number of grains in panicle was significantly and positively affected by the effect of salicylic acid. As well as, the concentration of 100 ppm has achieved the highest number of grains in panicle reached 51.51 grain.panicle^{-1}, followed by a concentration of 200 ppm with an average of 49.60 grain.panicle^{-1}, then the concentration of 300 ppm with an average reached 48.30 grain.panicle^{-1}. While the comparison treatment was recorded the lowest average for this trait was 47.15 grain.panicle^{-1}. These results were similar to (Azimi *et al.,* 2013) findings, that there is an increase in the number of grains in the spike with the effect of salicylic acid. The positive effect of salicylic acid in increasing the flag leaf area as shown in Table 4 may be reflected in the increase of the products of carbon representation and hence on the number of grains in panicle. The results also showed a significant interaction between growth stages and salicylic acid concentrations, where the highest mean of this trait was recorded at the (Z 22) stage and the concentration of 100 ppm was 55.06 grain.panicle^{-1}, while the same concentration but at the (Z 51) stage was recorded a lowest average of 48.90 grain.panicle^{-1}.

Table 6: Effect of growth stages, salicylic acid concentrations, and their interaction on number of grains in panicle (grain.panicle^{-1}).

Salicylic acid concentrations	Growth stage				Average
	Z 22	Z30	Z45	Z51	
0	47.72	47.33	46.72	46.85	47.15
100	55.06	52.28	49.82	48.90	51.51
200	53.64	49.00	48.27	47.49	49.60
300	52.57	47.53	46.56	46.56	48.30
L.S.D 5 %	1.62				LSD 5%
Average	52.25	49.03	47.84	47.45	
L.S.D 5 %	1.53				0.81

Weight of 1000 grains

The variance analysis results in table 7 data showed there were no significant differences in the weight of 1000 grains with the effect of adding stages. As indicated by the same data, the weight of 1000 grains were significantly affected by the salicylic acid effect, where the concentration of 100 ppm was superior significantly and achieved the highest average weight of 1000 grains amounted to 34.80 g, compared to the other concentrations. Furthermore, it was followed by a concentration of 300 ppm that significantly superior with an average of 33.18 g, then the concentration 200 ppm with an average of 32.95 g, while the comparison treatment decreased in this trait and recorded the lowest average was 30.50 g. A similar finding was obtained by (Fathi and Jiriaie, 2014; Ibrahim *et al.,* 2014; Ahmed *et al.,* 2018), which they pointed out there was an increase in weight of 1000 grains with the effect of salicylic acid. It is observed from Table 4 that salicylic acid at a concentration of 100 ppm caused an increase in the flag leaf area, since the flag leaf area contributes by 41 - 43% in the grain yield through contributing to increase the grain weight and the number of grains in the spike. (Ibrahim and AboElenein, 1977). Therefore, the increase in the weight of 1000 grains can be attributed to the increase in the flag leaf area (Table 4). In addition, salicylic acid accelerates chlorophyll formation and carbon metabolism and increases the effectiveness of some important enzymes (Morris *et al.,* 2006). It was also noted that there were no significant differences in the weight of 1000 grains with the effect of interaction the addition stages and the concentrations of acid.

Table 7: Effect of growth stages, salicylic acid concentrations, and their interaction on the weight of 1000 grains (g).

Salicylic acid concentrations	Growth stage				Average
	Z 22	Z30	Z45	Z51	
0	30.29	30.18	31.70	29.84	30.50
100	33.99	35.86	34.80	34.54	34.80
200	31.92	32.77	33.93	33.19	32.95
300	32.46	34.31	32.56	33.41	33.18
L.S.D 5 %	N. S				LSD 5%
Average	32.16	33.28	33.25	32.74	
L.S.D 5 %	N. S				1.029

Grain yield

There was a significant difference in grain yield with the effect of growth stages in which salicylic acid was added, this was shown by the variance analysis results in Table 8. The (Z 22) stage was significantly superior and achieved the highest average of 7.91 ton.h^{-1} compared to the (Z 45) stage and the (Z 51) stage only. Similarly, the (Z 30) stage was superior and recorded an average of 7.67 ton.h^{-1} compared to the (Z 51) stage that recorded an average of 7.14 ton.h^{-1}, which in turn did not differ significantly from the (Z 45) stage that recorded an average of 7.37 ton.h^{-1}. A similar finding was obtained by (Hussein and Al-baldawi 2015), which they pointed out that the addition of growth regulators including salicylic acid in begining of the tillering stage caused an increase in grain yield. The superiority of the (Z 22) stage in the number of grains in panicle as shown in Table 6 was positively reflected in increasing the grain yield. The same results showed that the salicylic acid had a significant and positive effect on the grain yield, where the concentration of 100 ppm achieved the highest average for this trait reached 8.43 ton.h^{-1} compared to other concentrations. It was followed by concentration 200 ppm with an average of 7.65 $ton.h^{-1}$ and then the concentration 300 ppm with an average of 7.40 $ton.h^{-1}$, while the comparison treatment recorded the lowest average amounted 6.62 $ton.h^{-1}$. This result was agreed with (Fathi and Jiriaie 2014; Ibrahim *et al.,* 2014) findings, that there was an increase in grain yield in wheat by the effect of salicylic acid. The number of grains and the weight of 1000 grains were significantly and positively affected by salicylic acid as shown in (Table 6 and 7), which reflected positively in increasing grain yield. The above results also show that there were no significant interactions in grain yield with the growth stages and salicylic acid concentrations.

Table 8: Effect of growth stages and salicylic acid concentrations and their interaction on the grain yield ($ton.h^{-1}$).

Salicylic acid concentrations	Growth stage				Average
	Z 22	Z30	Z45	Z51	
0	6.66	6.64	6.78	6.40	6.62
100	9.03	8.90	8.01	7.79	8.43
200	8.15	7.48	7.75	7.22	7.65
300	7.81	7.67	6.95	7.16	7.40
L.S.D 5 %	N. S				LSD 5%
Average	7.91	7.67	7.37	7.14	
L.S.D 5 %	0.48				0.31

Biological yield

The variance analysis results in Table 9 showed that the growth stages were significantly different in this trait, where the (Z 22) stage was significantly superior and achieved the highest average for this trait reached 24.39 $ton.h^{-1}$ compared to the other stages. It was followed by the (Z 30) stage with an average of 23.17 $ton.h^{-1}$ and then (Z 45) stage with an average of 22.41 $ton.h^{-1}$, while the (Z 51) stage recorded the lowest average was 21.94 $ton.h^{-1}$. A similar result obtained by (Hussein, 2015) that the external addition of growth regulators, including salicylic acid in the (Z22) stage has led to an increase in the biological yield. This was due to the superiority of beginning of the tillering stage in increasing the plant height, number of tillers, flag leaf area, number of grains in panicle, grain yield as shown in (Table 2, 3, 4, 6 and 8), which was reflected in increasing the biological yield. The same results also showed that the biological yield was significantly affected by salicylic acid, where the concentration of 100 ppm achieved the highest average that reached 24.91 $ton.h^{-1}$. Thus, it was superior on all other concentrations, followed by the concentration of 200 ppm that significantly superior with an average of 23.37 $ton.h^{-1}$, and then the concentration of 300 ppm with an average of 22.35 $ton.h^{-1}$. Whereas the comparison treatment recorded the lowest average of 21.28 $ton.h^{-1}$. This finding is consistent with (Fathi and Jiriaie, 2014 Ibrahim *et al.,* 2014) findings, that there was an increase in the biological yield with the effect of salicylic acid. The positive effect of salicylic acid on increasing dry weight as shown in Table 5 and grain yield in Table 8 was reflected in the increase of biological yield. There was a significant interaction with the effect of growth stages and salicylic acid concentrations, As the (Z 22) stage and the concentration of 100 ppm recorded the highest average of 26.36 $ton.h^{-1}$, while the same growth stage with the concentration of 300 ppm recorded a lowest average of 23.73 $ton.h^{-1}$.

Table 9: Effect of growth stages, salicylic acid concentrations and their interaction on the biological yield ($ton.h^{-1}$).

Salicylic acid concentrations	Growth stage				Average
	Z 22	Z30	Z45	Z51	
0	21.53	20.82	21.83	20.93	21.28
100	26.36	25.61	23.78	23.89	24.91
200	25.92	23.55	22.65	21.35	23.37
300	23.73	22.69	21.38	21.59	22.35
L.S.D 5 %	1.16				LSD 5%
Average	24.39	23.17	22.41	21.94	
L.S.D 5 %	0.46				0.58

References

Ahmed, H.W.L., M.F. Jan and M.D. Ahmedzai (2018). Effect of salicylic acid on yield and yield components of maize under reduced irrigation. *Agr. Research and Technology*, **15(2):** 1-5.

Amin, A.A., El-Sh. M. Rashad and Fatma, A.E. Gharib (2008). Changes in morphological, Physiological and Reproductive characters of Wheat plants as Affected by foliar application with Salicylic acid and Ascorbic acid. *Aust. J. of Basic and Appl. Sci.*, **2(2):** 252-261.

Anosheh, H.P. Emam, Y., Ashraf, M., and M.R. Foolad (2012). Exogenous application of salicylic acid and chlormequat chloride alleviates negative effects of drought stress in Wheat. *Adv. Studies in Biol.*, **4(11):** 501-520.

Azimi, M.S, J. Daneshian, S. Sayfzadeh and S. Zare (2013). Evaluation of amino aced and salicylic acid application on yield and growth of wheat under water deficit. *Intl. J. Agri. Crop. Sci.*, **5(7):** 709-712.

EL- Mougy, N.S. (2004). Preliminary evaluation of salicylic acid and acetysalicylic acid efficacy controlling root rot disease of lupin under greenhouse conditions. *Egypt. J. Phytopathol.*, **32(1-2):** 11-21.

FAO. (2017). www. FAOSTAT@fao.org.com.

Fath, A. and M. Jiriare (2014). Interaction of PGPR and water deficit stress on yield and protein percent in wheat adranced. *Crop ficence*, **4(4):** 82-92.

Hayat, S. and A. Ahmed (2007). Salicylic acid a plant hormone. Springer, Dordrecht, Netherlands: 401.

Hussein, H.T. (2015). Effect of some plant growth regulators, phytoextracts, and their spraying stages on grain filling duration, grain growth rate and grain yield of some bread wheat cultivars *Triticum aestivum* L. Phd. University of Baghdad-College of Agriculture.

Hussein, H.T. and M.H.K. Al-baldawi (2015). Effect of plant growth regulators and phytoextracts on growth and yield of three bread wheat cultivars *Triticum aestivum* L. *Euphrates Journal Of Agriculture Science*, **7(1):**73-83.

Ibrahim, H.A. and R.A. Abo Elenein (1977). Therelative contribution of different wheat leaves and awns to the grain yield and its protein content. Z.Zckerflanzenbau. **144:** 1-17.

Ibrahim, O.M., A.B. Bakry, A.T. Thalooth and M.F. El-Karamang (2014). Influence of Nitrogen fertilizer and folair application of salicylic acid on wheat. *Agricultural sciences*, **S:** 1316-1321.

Jini, D. and B. Joseph (2017). Salicylic Acid Mediated Salt Tolerance at Different Growth Stages of *Oryza Sativa* L. and its Effect on Salisylic Acid Biosynthetic Pathway Genes. *Bio Technology Journal*, **13(2):** 0974-7435.

Khan, N.A., S. Syeed, A. Massodi, R. Nazar and N. Iqbal (2010). Application of salicylic acid increases contents of nutrients and antioxidative metabolism in Mung bean and alleviates adverse effect of salinity stress. *Int. J. Plant Physiol*., **1(1):**1-8.

Kolupaev, Y.Y., K.T. Yastrep, Y.V. Karpets and N.N. Mirochenko (2011). Influence of Salicylic acid and succinic acid on antioxidant enzymes activity, heat resistance and productivity of *Panicum miliaceum* L. *J. stress physiol. Boichem*., **7(2):**154-163.

Metwally, A., I. Finkmemeier, M. Georgi and K.J. Dietz (2003). salicylic acid alleviates the cadmium toxicity in barley seedlings. *Plant Physiology*, **132:** 272-281.

Morris, K., S. A. H. Mackerness and T. Page (2006). salicylic acid has a role in regulating gene expression during leaf senescence. *Plant J.*, **23:** 677-685.

Park, S.W. P., Liu, F. Forouhar, A.C. Vlot, L. Tong and F. Klessig (2009). Use of a synthetic salicylic acid analog to investigate the roles of methyl salicylate and its esterases in plant disease resistence. *J. Biol. Chem*., **284:** 303-317.

Raskin, I. (1992). Role of salicylic acid in plants. *Annual Review Plant Physiology*, **43:** 439-463.

Roa, S.R. Qayyum, A. Razzaq, M. Ahmad., I. Mamood and A. Sher (2012). Role of Folir Application of Salicylic Acid and L-Tryptophan in Drought Tolerance of Maize. *The Journal of Animal*, **22(3):** 768-772.

Steel, R.G.D. and J.H. Torrie (1980). Principles and Procedures of Statistics. A biometrical Approach 2 and ed. McGraw, Hill Book Co. USA. P : 481.

Sterna, V., S. Zute, I. Jansone, L. Bruvava and L. Kantane (2015). Oat Grain Functional Ingredient Characterization. Agricultural. *International Journal of Biological*, **9(7).**

Tufail, A.M. Arfan, A. Gurmani, K. Abdullah and A. Bano (2013). Salicylic Acid Induced Salinity Tolerance in Maize (*Zea Mays*). *Pak. J. Bot*., **45(s1):** 75- 82.

Yusuf, M., H. Shamsul, N. Mohammed, Q.F. ALyemeni and A. Ahqil (2013). Salicylic Acid. *Physiological Roles in plants*. Chapter No. 2,1- 16.