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(Original Article)

Response of Faba Bean *(Vicia faba* L.) Growth and Productivity to Foliar Application of Salicylic Acid and Zinc Application Methods under Upper Egypt Conditions

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Abstract

Two field experiments were carried out during the agricultural successive seasons (2020/2021 and 2021/2022) in the Agric., Farm of Assiut Univ., Egypt. This investigation aimed to study the effect of spraying methods on two faba bean varieties with different concentrations of salicylic acid (SA) and zinc on the growth and yield. The experiment was designed in split split plot design with three replicates. The first factor included faba bean varieties (Giza 843 and Giza 40) while the second factor included spraying with three concentrations of salicylic acid (0, 100 and 200 ppm. The third factor included two zinc application methods: soil application as Zinc sulphate at a rate of (5 kg/fed) at soil preparing, and foliar application at a rate of 50 mg Zn L^{-1} of EDTA (13%). Statistical results revealed that Giza 843 variety appeared to be preferred over Giza 40 in all growth and yield parameters. The obtained data indicated that growth and yield parameters increased significantly by increasing SA concentration from 100 ppm to 200 ppm in comparison to the control treatments in both seasons. Data also revealed that both zinc applications methods had a significant effect on growth and yield of faba bean as compared with the control. Also, spraying bean plants by 50 ppm zinc (EDTA) gave the maximum values of growth and yield parameters compared to soil addition with zinc sulphate. The study concluded that the combined foliar application of 200 ppm SA and 50 ppm zinc spray recorded the maximum growth and yield of Giza 843 variety under the conditions of Assiut Governorate.

Keywords: *Faba bean, Foliar application, Productivity, SA, Spraying, Zn.*

Introduction

Faba bean crop is the most important leguminous crops that all people depend on as a necessary and cheap food source in Egypt. Despite the importance of faba bean crop to the Egyptian people, the local production of it does not meet the requirements of national consumption, due to the decrease in the cultivated area of yearly by an annual amount of about 11.68 thousand acres, Consequently, the total production decreased at an annual rate of about 15.71 thousand tons per year, which led to an increasing food gap between what is produced and consumed from this crop, which led to an increasing trend in the volume of imports to meet the requirements of national consumption, which is consistent with economic logic. (Al-Suwaina, *et al*. 2022). It is considered a significant source of protein, reaching a percentage of 28%, and it is the cheapest type of protein. It also contains carbohydrates and many vitamins and nutrients, in addition

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to the benefits of growing it in the soil. The properties of the soil are improved by the process of atmospheric nitrogen fixation, which reduces utilization of chemical-nitrogen fertilizers and their cost. It is also used to make animal feed with high nutritional value (Abdul Sadiq, 2019). The agricultural policy in Egypt depends on the vertical expansion of the production process through the development of high-quality varieties of faba beans. These agricultural practices include foliar spraying with growth regulators and fertilizing with micro-nutrients, which aim to maximize the productivity of local beans to cover the gap between production and consumption.

Salicylic (SA), a type of small-molecule phenolic compound, is regarded as a plant endogenous signal molecule (Yan and Dong, 2014). SA is primarily found in plant tissues and can influence a wide range of physiological processes, primarily controlling plant growth, photosynthetic capacity, and development (Berkowitz *et al.,* 2016). Previous studies reported that low concentrations of SA appear to be beneficial to plant metabolism.

Salicylic acid treatment affected the nutrient balances in plant as reported by Borsani *et al*. (2001) who emphasized that exogenous application of SA resulted in a significant increase in plant growth both in saline and non-saline conditions. Al-Alawy *et al.* (2020) stated that Foliar application of faba bean by salicylic acid and ascorbic acids (25 and 50 mg/L) led to increase of plant height, fresh weight of shoot, dry weight of shoot and fresh weight of the pod comparison with control, all treatments were significantly increase of dry weight of pod except for the treatment of the first concentration of salicylic acid (SA). Moreover, Ahmad *et al*. (2023) studied the effect of two factors: amino acid (Glycine) and salicylic acid each having four levels that were sprayed on peas. They found that salicylic acid levels showed that maximum germination percentage (95.83 %) height of plants (71.85 cm), leaves plant^{-1} (257.13), primary branches plant^{-1} (3.25), leaf chlorophyll content (55.81 SPAD), pods plant^{-1} (52.16), seeds pod^{-1} (10.91), pod length (11.05 cm) and yield ha^{-1} (1895.0 kg) having least days to pod formation and flowering (5.26 and 48.30 days) were noted in salicylic acid level of 300 mg L^{-1}.

Zinc is considered an important micro-nutrient in plants due to its role in the growth of the plant by affecting many biological processes such as formation of enzymes and proteins in addition to contributing to the processes of carbohydrate metabolism that increases photosynthesis process (AL-Isawi, 2010). It also affects the synthesis of some amino acids, hormones and many important enzymes in oxidation and reduction reactions and acting as a catalyst and promoter for plant growth regulators such as (IAA) (Brian, 2008).

Moreover, Al-Shumary (2020) showed that zinc spraying at concentration of 75 mg/l resulted in an increase in growth and yield characteristics, giving the highest plant height (97.11cm), number of branches (5.78branches/plant). Number of pods (11.23 pods/plant), number of seeds/pods (5.18 seeds/pod), 100-seed weight (122.98 g) and seed yield (7014.07 kg/ ha). Local variety was superior in plant height (92.75 cm), number of branches (5.70 branches/plant), number of pods (10.26 pods/plant), number of seeds/ pods (4.73 seeds/pod) and seed yield (6554.68 kg/ha).

Alhasany *et al* (2019) showed significant increase of zinc concentrations (0, 40, and 80 mg Zn L^{-1}) in the spray solution, on the growth and yield of faba bean. They indicated that the concentration (80 mg Zn L^{-1}) increased most studied traits such as plant height, the number of branches, and also some yield components, the pods were 15.32, the number of seeds by pods was 5.12, the total number of seeds was 4628 Kg^{-1}

Moreover, Reda *et al* (2014) indicated that spraying faba bean plants two times with 7 days interval between each spraying with Zinc Sulphate ($ZnSO_4$) at concentrations of 30 and 60 mg/l. significantly increased growth, especially at the higher dose of $ZnSO_4$.

Materials and Methods

Two field experiments were carried out during the agricultural successive seasons (2020/2021 and 2021/2022) in the Agric. Farm of Assiut Univ., Egypt. This investigation aimed to study the effect of spraying two faba bean verities with different concentrations of salicylic acid and zinc applying methods on the growth and yield of faba bean. The experiment was designed in split split plot design with three replicates. The first factor included faba bean varieties (Giza 843 and Giza 40), The second factor included spraying with three concentrations of salicylic acid (0, 100 and 200 ppm). Meanwhile, the third factor included two zinc application methods: soil application by Zinc sulphate at a rate of (5 kg/fed) at soil preparing and by foliar application at a rate of 50 mg Zn L^{-1}) using EDTA (13%).

Prior to planting, some chemical and physical analyses were determined for the field of experiment as described in table 1. The soil of experiments was plowed followed by leveling then ridged and divided into experimental units; each contained 5 ridges with total area of 10.5m^2. Seeds were sown on both sides of ridge in hills containing 2 seeds/hill and the distance between hills was 20 cm. Seeds were sown on 19th of November 2020 and 21st of November 2021 for two experimental seasons.

Table 1. Some physical and chemical properties of the soil in both seasons.

Year	Sand %	Silt %	Clay %	Texture	pH 1:1	ECe dS/m	Total $CaCO_3$ %
20/2021 (S1)	**19.3**	31.0	49.7	Clay	7.50	1.42	2.13
2021/2022 (S2)	**21**	29.4	49	Clay	8.11	1.13	3.25

Year	Total N %	Available nutrients ppm				
		P	K	Fe	Mn	Zn
2020/2021 (S1)	1.80	15.7	354	10.7	9.3	1.0
2021/2022 (S2)	1.88	13.2	325	8.6	8.0	1.1

All cultural practices (fertilization, irrigation and weeding operations) were followed as recommended. Spraying was carried out after the preparation of the concentrations used in the spray solution for both salicylic acid and zinc, based on the quantity of water (200 liters fed^{-1}). The concentrations of salicylic acid and zinc were applied when the plant reached 50% flowering. Spraying was conducted mediated sprinkler dorsal, taking into account spraying times during the morning or evening to avoid high temperatures; a detergent solution was added to the solution to reduce the surface tension of the water and to ensure complete wetness of the leaves in order to increase the efficiency of the spray solution.

The second application method of Zinc was soil application which is by Zinc sulphate at a rate of (5 kg/fed) at soil preparing.

Five plants were randomly taken from each plot at harvest to determine the following characteristics:

1-Plant height, cm.

2-Number of branches per plant,

3-Number of pods per plant.

4-Number of seeds per pod.

5-Seed yield per plant.

6-Seed Index.

7-Seed yield per faddan was determined from the two middle ridges of each plot and converted to seed yield, in ardab per faddan. (1 ardab = 155 Kg, 1 feddan = 4200m^2).

Statistical Analysis

Data analysis was done using ANOVA statistical analysis. The LSD test at 0.05 levels according to Snedecor and Cochran (1980) was used.

Results and Discussion

1-Effect of treatments on growth of faba bean

Main effects

Data in table 2 indicated that, generally, all growth parameters of faba bean were highly significantly affected by treatments. Giza 843 variety appeared to be preferred over the other var. Giza 40. Giza 843 var. percentage surpass over Giza 40 in number of branches/plant, number of pods/plant and number of seeds/pods by (34.82 and 47.29%), (26.55 and 25.42%) and (13.99 and 13.30%) in the 1st and 2nd seasons, respectively. It may be attributed to the fact that growth parameters are greatly influenced by the variety's genetic makeup. These results agree with Wolday (2018). Similar results were obtained by El-Shafe *et al.* (2020) who reported superiority of Giza 716 than Giza 40 in shoot weight / plant No. pods/plant, Seed and weight/plant (g), 100- seed weight (g) and Seed yield/fed (kg).

Regarding the effects of foliar application of SA on faba bean growth parameters, the results in table 2 clearly show that SA had a significant effect on all characters in both seasons. The data obtained indicated that growth parameters increased significantly with increasing SA concentration from 100 ppm to 200 ppm in comparison to the control treatments in both seasons. Spraying SA recorded the maximum values of growth parameters in both seasons. The increase percentage for spraying 200 ppm SA reached (11.41 and 11.64%) for plant height, (35.30 and 34.36%) for number of branches/plant, (45.65 and 41.66%) for number of pods/plant and (28.23 and 27.96%) for number of seeds /pod., in the 1st and 2nd seasons, respectively.

The increase in growth parameters of faba bean plants may be due to the increase in the rate of cell division in the apical meristem of the roots, which leads to increased

plant growth (Amin *et al.,* 2008). similar findings were observed by Al-Hilfy, *et al.* (2017) who found that the SA concentrations had significant effect on plant height, and the highest plant was obtained from 70 ppm SA concentration (131.9 cm) which was significantly different from that 35 ppm SA (117.8 cm) and control treatment (108.4 cm).Additionally, El-Shafe *et al*., (2020) when using SA at 200 ppm recorded that shoot dry weight/ plant after 75 and 95 days reached (9.78 and 10.50) (18.38 and 17.93) in both seasons No. pods/plant Seed weight/plant (g) 100- seed weight (g) Seed yield/fed (kg).

In respect of Zn application methods, the data in table 2 reveal that both soil application (Z1) and foliar spray (Z2) had a significant effect on growth of faba bean as compared with the control. Both applications of Zn significantly increased growth of faba bean but foliar application recorded the highest values for the growth of bean plants. Spraying bean plants by 50 ppm zinc (EDTA) gave the maximum value of growth parameters under the study. Foliar application of Zn surpassed soil application in plant height by (9.35 and 9.15%), No. of branches /plant by (53.85 and 48.17 %), No. of pods/plant by (23.38 and 21.49 %), No. of pods /plant by (40.90 and 37.78 %) in both seasons, respectively. This significant increase is probably due to the synthesis process, which is increased by increasing the supply of zinc, which led to an increase in the growth parameters (Alhasany, 2019). Moreover, this may be due to the function of zinc which contributes to the growth and the efficiency of the photosynthesis process and thus increases dry matter production leading to increased plant growth. In general, this result agreed with

Table 2. Main effects of treatments on some growth characteristics of Faba Bean in 2020/2021 and 2021/2022 seasons.

Main effect Charac.	Plant height (cm)		Number of branches/plant		Number of pods/plant		Number of seeds/pod	
	S1	S2	S1	S2	S1	S2	S1	S2
Var. (V)								
Giza 843	113.86	120.41	4.449	4.714	14.59	15.64	3.202	3.304
Giza 40	77.30	81.62	3.300	3.476	11.45	12.47	2.809	2.916
F-test	**	**	**	**	**	**	**	**
SA (S)								
Control	90.47	95.25	3.300	3.507	10.58	11.57	2.595	2.682
Sa 100ppm	95.46	101.46	3.858	4.067	13.08	14.21	3.092	3.217
Sa 200ppm	100.79	106.34	4.465	4.712	15.41	16.39	3.330	3.432
F-test	**	**	**	**	**	**	**	**
LSD 5%	2.36	2.18	0.112	0.107	1.37	1.28	0.089	0.082
Zin (Z)								
Control	90.98	96.10	3.003	3.218	11.42	12.47	2.440	2.562
Z1	96.26	102.06	4.000	4.298	13.55	14.55	3.138	3.238
Z2	99.49	104.89	4.620	4.768	14.09	15.15	3.438	3.530
F-test	**	**	**	**	**	**	**	**
LSD5%	2.71	2.57	0.136	0.118	1.51	1.47	0.096	0.089

The increase due to foliar application than soil application might be due to high effectiveness where plant stomata of these leaves are usually faster in their nutrient uptake comparing with soil application (Smoleń, 2012). Another explanation revealed that foliar application influence plant metabolism such as gene regulation, protein synthesis, carbohydrate metabolism, and photosynthesis (Rehman *et al*., 2018) Effects

can also be attributed to the fact that micronutrients such as Zn and Mg are key important elements in many enzymatic reactions leading to production of proteins, vitamins, leaf photosynthesis rates, and optimization of plant cell metabolism by amino acid (Marschner, 2011)

Effect of the 2nd order interactions

Regarding the interaction between SA and Zn application**,** the results in Table 3 indicated that all growth parameters were highly significantly affected by all 2nd interactions. The combination of (Var Giza 843 × 200 ppm SA), (Var Giza 843 × 50 ppm Zn2) and (200 ppm SA × 50 ppm Z2) were superior in all growth parameters; plant height, No. of branches /plant, No. of pods/plant, and No. of pods/plant, while the control gave the lowest growth values in both seasons.

Table 3. The 2nd interaction effects of treatments on some growth characteristics of Faba Bean in 2020/2021 and 2021/2022 seasons.

Effect of interaction treatments		Plant height (cm)		Number of branches/plant		Number of pods/plant		Number of seeds/pod	
		S1	S2	S1	S2	S1	S2	S1	S2
Ver. (V vs (Sa)									
Giza 843 cv	**C**	107.1	112.3	3.983	4.283	11.33	12.50	2.703	2.783
	Sa **1**	113.7	121.2	4.320	4.513	14.74	15.82	3.340	3.487
	Sa **2**	120.8	127.8	5.043	5.347	17.69	18.60	3.563	3.643
Giza 40 cv	**C**	73.88	78.19	2.617	2.730	9.823	10.64	2.487	2.580
	Sa **1**	77.25	81.76	3.397	3.620	11.42	12.60	2.843	2.947
	Sa **2**	80.75	84.91	3.887	4.077	13.12	14.17	3.097	3.220
F-test		**	**	**	**	**	**	**	**
LSD 5%		2.63	2.39	0.117	0.113	1.43	1.32	0.092	0.085
Ver. (V) vs (Z)									
Giza 843 cv	**C**	108.9	114.9	3.710	3.970	13.43	14.63	2.627	2.760
	Z1	114.2	121.3	4.550	4.937	14.93	15.85	3.297	3.393
	Z2	118.5	125.0	5.087	5.237	15.40	16.43	3.683	3.760
Giza 40 cv	**C**	73.05	77.26	2.297	2.467	9.413	10.30	2.253	2.363
	Z1	78.32	82.79	3.450	3.660	12.16	13.25	2.980	3.083
	Z2	80.51	84.81	4.153	4.300	12.79	13.86	3.193	3.300
F-test		**	**	**	**	**	**	**	**
LSD5%		2.78	2.63	0.143	0.122	1.57	1.51	0.102	0.094
(Sa) vs (Z)									
C	**C**	87.31	91.46	2.570	2.770	9.020	9.850	2.120	2.25
	Z1	90.16	95.58	3.215	3.485	10.88	11.87	2.550	2.615
	Z2	93.86	98.71	4.115	4.265	11.83	12.99	3.115	3.180
Sa1	**C**	90.71	96.58	2.980	3.225	11.41	12.55	2.465	2.590
	Z1	96.32	102.7	3.965	4.250	13.88	14.92	3.315	3.450
	Z2	99.36	105.1	4.630	4.725	13.95	15.16	3.495	3.610
Sa2	**C**	94.91	100.3	3.460	3.660	13.84	15.01	2.735	2.845
	Z1	102.3	107.9	4.82	5.160	15.88	16.86	3.550	3.650
	Z2	105.2	110.8	5.115	5.315	16.50	17.29	3.705	3.800
F-test		**	**	**	**	**	**	**	**
LSD 5%		2.81	2.65	0.145	0.124	1.59	1.54	0.104	0.096

**: significant differences at 0.01.

Effect of the 3rd order interaction

The 3rd interaction between faba been varieties, SA foliar application and Zn application methods had highly significant effect on all growth characters in both seasons (Table 4). Data shows clearly in Table 3 that the foliar application of Giza 843

by 200 ppm SA and by 50 ppm zinc (EDDTA) recorded the maximum values of growth parameters under the study in comparison to Giza 40 Var. These results led to considering that Giza 843 Var. as a superior variety than Giza 40 under these conditions.

Table 4. Effect of the 3rd interaction between faba bean varieties, SA foliar application and Zn application methods, on growth parameters of faba bean in 2020/2021 and 2021/2022.

Effect of interaction treatments			Plant height (cm)		Number of branches/plant		Number of pods/plant		Number of seeds/pod	
V	SA	Z	S1	S2	S1	S2	S1	S2	S1	S2
Giza 843	Cont.	C	102.3	106.4	3.310	3.670	10.42	11.57	2.210	2.320
		Z1	106.7	112.7	4.120	4.510	11.23	12.36	2.530	2.610
		Z2	112.2	117.8	4.520	4.670	12.34	13.57	3.370	3.420
	Sa100	C	108.1	115.2	3.620	3.780	13.55	14.76	2.560	2.720
		Z1	114.4	122.7	4.210	4.540	15.43	16.23	3.670	3.830
		Z2	118.5	125.6	5.130	5.220	15.23	16.46	3.790	3.910
	Sa200	C	116.3	123.2	4.200	4.460	16.32	17.57	3.110	3.240
		Z1	121.5	128.6	5.320	5.760	18.13	18.96	3.690	3.740
		Z2	124.7	131.5	5.610	5.820	18.62	19.27	3.890	3.950
Giza 40	Cont.	C	72.32	76.51	1.830	1.870	7.62	8.13	2.030	2.180
		Z1	73.61	78.45	2.310	2.460	10.53	11.37	2.570	2.620
		Z2	75.71	79.61	3.710	3.860	11.32	12.41	2.860	2.940
	Sa100	C	73.32	77.96	2.340	2.670	9.26	10.34	2.370	2.460
		Z1	78.23	82.65	3.720	3.960	12.32	13.61	2.960	3.070
		Z2	80.21	84.67	4.130	4.230	12.67	13.86	3.200	3.310
	Sa200	C	73.52	77.32	2.720	2.860	11.36	12.44	2.360	2.450
		Z1	83.12	87.26	4.320	4.560	13.63	14.76	3.410	3.560
		Z2	85.62	90.15	4.620	4.810	14.37	15.31	3.520	3.650
F-test			**	**	**	**	**	**	**	**
LSD5%			2.97	2.84	1.432	1.327	1.71	1.62	0.102	0.096

**: significant differences at 0.01.

It is known that Salicylic acid plays a great role in stimulating the flowering process, increasing the lifespan of the flower, delaying senescence, increasing the rate of cell metabolism, and regulating several physiological processes depending on its concentration and zinc leading to increasing many enzymes involved in the processes which contribute to increasing the content of the leaves of chlorophyll. Zinc activates enzymes, in particular, the enzymes that are responsible for building and configure the molecule chlorophyll thus increased its content in leaves, these results agreed with AL-Isawi (2010). In Addition, Zinc affects the proteins and metabolism of carbohydrates, and this effect is directly related to the processes of sugar conversion and also affects the process of photosynthesis and this has an important role in providing carbohydrates and proteins necessary for the process of growth of vegetative parts and production of reproductive parts (Marschner, 1995).

Due to genetic makeup of the varieties under the study and the role of SA and Zn applications, it could be concluded that spraying Giza 843 Var. with 200 ppm SA combined with 50 ppm zinc (EDTA) gave the maximum growth and seed yield of faba bean crop.

2-Effect of treatments Application on mean values of faba bean yield and its components

Main effects

Data in Table (5) showed that Giza 843 cv. had higher yield parameters than Giza 40; the increase percentage were (14.36 and 12.87 %), (48.61 and 12.18 %), (15.80 and 10.77 %), and (12.66 and 14.08%) for seed yield/plant, seed index, seed yield/ard/fed and protein in comparison to Giza 40 cv the 1st and 2nd seasons, respectively.

Table 5. Main effects of treatments on some growth characteristics of Faba Bean in 2020/2021 and 2021/2022

Main effect Characteristics	Seed yield/plant g		Seed index 100s g		Seed yield/ard/fed	
	S1	S2	S1	S2	S1	S2
Giza 843 cv	57.80	61.13	74.13	77.47	10.70	11.00
Giza 40 cv	50.54	54.16	66.42	69.06	9.237	9.931
F-test	**	**	**	**	**	**
Control	38.14	41.41	65.63	68.80	8.840	9.285
Sa 100ppm	58.31	62.01	69.90	73.23	9.657	10.20
Sa 200ppm	66.06	69.52	75.30	77.76	11.41	11.91
F-test	**	**	**	**	**	**
LSD 5%	2.37	2.29	1.98	1.85	0.63	0.57
Control	48.09	51.66	65.83	69.24	9.037	9.502
Z1	53.70	57.12	71.07	73.65	10.06	10.52
Z2	60.73	64.17	73.93	76.90	10.82	11.38
F-test	**	**	**	**	**	**
LSD5%	3.12	2.98	2.12	1.98	0.67	0.62

**: significant differences at 0.01.

The results indicated that spraying SA (100 and 200 ppm) significantly increased the mean values of faba bean yield parameters than control treatment. Spraying SA at a rate of 200 ppm had the highest values of Seed yield/plant, Seed index 100s, Seed yield/ard/fed and Protein. Also, spraying faba bean plants by SA (200 ppm) recorded (66.06 and 69.52 g/plant) compared to the values of the control treatment (38.14 and 41.41 g/plant) in the 1st and 2nd seasons, respectively. Mean values of Seed Index of faba bean as affected by varieties, spraying SA and Zn application methods in both seasons. Table (4) revealed that spraying Giza 843 significantly increased seed Index by (14.73 and 13.02 %) in comparison to Giza 40 cv the 1st and 2nd seasons, respectively. In this respect, Al-Hilfy *et al* (2017) revealed significant differences between varieties concerning growth and yield, the Local variety gave highest yield about 3830 Kg ha-1.

Regarding the mean values of seed yield/ardab/fed as affected by varieties, Sa, and Zn applications, spraying bean plants by 200 ppm SA recorded the highest values (11.41 and 11.91 ardab/fed) in both seasons. Similar results were reported by Al-Hilfy *et al* (2017) who revealed that increasing salicylic acid from 0 to 70 ppm increased plant height, chlorophyll content, leaf area, yield and some yield components. In relation to Protein percentages, data revealed that spraying bean plants by 200 ppm SA recorded the highest percentages (23.84 and 23.87 %) in comparison to the control treatment in both seasons, respectively.

Mean values of yield and its components content significantly affected by varieties, SA, and Zn application methods in both seasons. Seed yield/plant, Seed index

100s and Seed yield/ard/fed were increased by (26.28 and 24.22%), (12.30 and 11.06 %), and (19.73 and 19.79 %) compared to the control treatment in the 1st and 2nd seasons, respectively.

Additionally, the results indicated the significant effect of spraying with zinc on seed parameters, as giving the highest average value of number of seed yield/plant, seed index, and seed yield were (60.76 and 64.76), (73.93 and 76.90), and (10.82 and 11.38), while the control treatment Zn 0 gave the lower average for all these characteristics (Table 5). It may be attributed to the fact that zinc affects the proteins and metabolism of carbohydrates, and this effect is directly related to the processes of sugar conversion and affects the process of photosynthesis, and this has an important role in providing carbohydrates and proteins necessary for the process of growth of vegetative parts and production of reproductive parts (Marschner, 1995). This result agreed with Al-Isawi (2010).

Obtained results in Table (5) and Fig.1 indicate that all second order interactions between (Var × SA), (Va × Zn) or (SA × Zn) had highly significant effect on Seed yield/plant, Seed index, and Seed yield/ard/fed.

Table 6. The 2nd interaction effects of treatments on some growth characteristics of Faba Bean in 2020/2021 and 2021/2022.

Effect of interaction treatments		Seed yield/plant gm		Seed index 100s gm		Seed yield/ard/fed	
		S1	S2	S1	S2	S1	S2
Giza 843 cv	C	41.94	44.92	67.73	71.20	9.27	9.48
	Sa 1	61.59	65.13	73.37	77.48	10.13	10.38
	Sa 2	69.86	73.34	81.29	83.72	12.71	13.14
Giza 40 cv	C	34.34	37.90	63.52	66.40	8.41	9.09
	Sa 1	55.03	58.89	66.43	68.97	9.18	10.02
	Sa 2	62.25	65.70	69.30	71.81	10.11	10.69
F-test		**	**	**	**	**	**
LSD 5%		2.41	2.33	2.01	1.92	0.68	0.64
Giza 843 cv	C	51.24	54.83	68.06	71.80	9.67	9.92
	Z1	57.74	60.78	75.08	77.83	10.76	11.07
	Z2	64.41	67.79	79.25	82.77	11.69	12.01
Giza 40 cv	C	44.93	48.48	63.59	66.68	8.41	9.09
	Z1	49.65	53.46	67.05	69.47	9.36	9.97
	Z2	57.04	60.54	68.61	71.02	9.94	10.74
F-test		**	**	**	**	**	**
LSD5%		3.17	3.02	2.17	2.03	0.72	0.67
C	C	31.13	34.33	64.05	66.69	8.33	8.74
	Z1	35.81	56.45	65.39	68.29	8.84	9.25
	Z2	47.49	64.19	67.45	71.43	9.36	9.87
Sa1	C	52.92	39.35	65.89	70.03	8.78	9.22
	Z1	58.33	61.61	70.47	73.18	9.84	10.42
	Z2	63.68	70.41	73.35	76.47	10.35	10.97
Sa2	C	60.22	50.55	67.54	71.02	10.01	10.55
	Z1	66.95	67.98	77.35	79.48	11.50	11.91
	Z2	71.01	73.98	81.01	82.79	12.74	13.29
F-test		**	**	**	**	**	**
LSD 5%		3.19	3.04	2.18	2.04	0.73	0.71

**: significant differences at 0.01.

Effect of the 2nd interactions

Concerning the interaction between SA and Zn application, the results in Table 6 indicated that all growth parameters highly significantly affected by all 2nd interactions. The combination of (Var Giza 843 × 200 ppm SA), (Var Giza 843 × 50 ppm Z2) and (200 ppm SA × 50 ppm Z2) were superior in all growth parameters; plant height, No. of branches /plant, No. of pods/plant, and No. of pods/plant, while the control gave the lowest growth values in both seasons.

Effect of the 3rd interactions

The data in Table (7) show clearly that seed yield/plant, seed index, and seed yield/ard/fed were significantly affected by all treatments under the study. The maximum values of all characters under both cultivars occurred as results of the combined foliar application of 200 ppm SA and 50 ppm Zn.

Table 7. Effect of the 3rd interaction between faba bean varieties, SA foliar application and Zn application methods, on yield parameters and protein of faba bean in 2020/2021 and 2021/2022.

Effect of interaction treatments			Seed yield/plant gm		Seed index 100s gm		Seed yield/ard/fed	
V	SA	Z	S1	S2	S1	S2	S1	S2
Giza 843	Cont.	C	34.62	37.42	65.75	68.61	8.530	8.760
		Z1	40.45	43.62	67.20	70.35	9.310	9.450
		Z2	50.76	53.72	70.23	74.65	9.960	10.23
	Sa100	C	56.32	59.41	68.11	73.24	9.130	9.270
		Z1	61.32	64.57	73.79	76.82	10.32	10.72
		Z2	67.12	71.42	78.22	82.37	10.94	11.16
	Sa200	C	62.79	67.65	70.32	73.56	11.34	11.72
		Z1	71.45	74.14	84.26	86.31	12.64	13.05
		Z2	75.35	78.24	89.30	91.28	14.16	14.65
Giza 40	Cont.	C	27.64	31.24	62.34	64.76	8.120	8.720
		Z1	31.16	35.08	63.57	66.23	8.360	9.040
		Z2	44.22	47.37	64.66	68.21	8.760	9.510
	Sa100	C	49.51	53.49	63.67	66.82	8.430	9.160
		Z1	55.34	58.64	67.14	69.54	9.360	10.11
		Z2	60.24	64.53	68.47	70.56	9.760	10.78
	Sa200	C	57.64	60.72	64.76	68.47	8.670	9.380
		Z1	62.45	66.67	70.44	72.65	10.36	10.76
		Z2	66.67	69.71	72.71	74.30	11.31	11.92
F-test			**	**	**	**	**	**
LSD5%			3.41	3.27	2.31	2.23	0.75	0.68

**: significant differences at 0.01.

The increases in seed yield/fed in the Giza 843 cv seeds obtained at the combination of SA (200 ppm) + Zn (50 ppm) (Table 5) significantly helped to recommend expanding the cultivation of this variety.

The combined effect of SA acid and Zn on faba bean plants was additive and synergetic, especially at this concentration.

The results also show the superiority of the Giza 843 cv., over the Giza 40. Supporting these results was agreed with Reda *et al* (2014) who concluded their study that foliar treatment of faba bean plants with the combination of B and Zn (60 mg/l of each) could positively alleviate the decreases in vegetative growth and seed yield of

plants irrigated with saline water equivalent (4000 ppm). In addition, tolerance of faba bean treated with B + Zn to salinity could be interpreted by the improvement and increases in the contents of photosynthetic pigments, proline, soluble sugar, and amino acids, antioxidants (total phenolic compounds and total flavonoids). These outcomes follow the same pattern as those attained by Bakry *et al.* (2015)

Recommendations

To maximize growth and yield of Faba bean crop, it could be recommended to use 200 ppm salicylic acid and 50 ppm zinc in form of EDTA as foliar applications at 50% flowering. Furthermore, there is a need to encourage farmers in Upper Egypt to grow faba bean Giza 843 for optimum growth and yields.

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استجابة نمو وإنتاجية الفول البلدي للرش الورقي بطرق الرش بحمض الساليسيليك والزنك تحت ظروف مصر العليا

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الملخص

تم تنفيذ تجربتين حقليتين خلال الموسمين الزراعيين المتتاليين (2021/2020، 2022/2021) بمزرعة كلية الزراعة- جامعة أسيوط. يهدف هذا البحث إلى دراسة تأثير رش صنفين من الفول البلدي بتركيزات مختلفة من حمض الساليسيليك وطرق مختلفه لاضافة الزنك في نمو وإنتاجية الفول البلدي. صممت التجربة بتصميم القطع المنشقة بثلاثة مكررات.

شمل العامل الأول الرش بأنواع الفول البلدي (الجيزة 843 والجيزة 40)، أما العامل الثاني فقد شمل الرش بثلاثة تراكيزات من حمض الساليسيليك (0، 100، 200) جزء في المليون. وتضمن العامل الثالث طريقتين لاضافة الزنك بالاضافه الارضيه بكبريتات الزنك بمعدل (5 كجم/فدان) عند تحضير التربة وطريقة أخرى بالرش الورقي بمعدل 50 ملجم زنك لتر$^{-1}$) باستخدام (EDTA 13%).

أظهرت النتائج الإحصائية تفضيل الصنف جيزة 843 على الصنف جيزة 40 في جميع معايير النمو والإنتاج. أشارت البيانات المتحصل عليها إلى زيادة معنوية في مؤشرات النمو والإنتاج مع زيادة تركيز SA من 100 جزء في المليون إلى 200 جزء في المليون مقارنة بمعاملات المقارنة في كلا الموسمين. كما أظهرت البيانات أن كلا من الرش بالتربة (Z1) والرش الورقي (Z2) كان لهما تأثير معنوي في نمو وحاصل الفول البلدي مقارنة بالكنترول. كما أن رش نباتات الفول بـ 50 جزء بالمليون من الزنك (EDTA) أعطى أعلى قيم النمو والحاصل مقارنة بإضافة التربة بكبريتات الزنك. وخلصت الدراسة إلى أن الرش الورقي المشترك بـــ 200 جزء في المليون SA و50 جزء في المليون من الزنك سجل أعلى نمو وإنتاجية لصنف جيزة 843 تحت ظروف محافظة أسيوط

الكلمات المفتاحية: *الإنتاجية، الرش الورقي، الزنك، الفول البلدي، المحصول، النمو*