Assiut Journal of Agricultural Sciences 54 (4) 2023 (41-51)
ISSN: 1110-0486 / EISSN: 2356-9840
Website: http://ajas.journals.ekb.eg/
E-mail: ajas@aun.edu.eg

(Original Article)

Response of Faba Bean Seed Yield and its Components to Foliar Spray by Some Growth Regulators

Elmahdy A. Teama; Adel M. Mahmoud; El-Saadi A. Ali and Reda Abou El-Mahasen*

Agronomy Department, Faculty of Agriculture, Assiut University, Egypt.

*Corresponding author email: reda3c@gmail.com
DOI: 10.21608/AJAS.2023.228191.1288

Abstract

This study was conducted at the Agronomy Experimental Farm, Faculty of Agriculture, Assiut University during the two growing seasons of 2020/2021 and 2021/2022 to investigate the response of faba bean seed yield and its components to foliar spray by various growth regulators. The experiment was carried out in randomized complete block design (RCBD) with three replications utilizing a strip plot configuration. The foliar sprays (Control, Indole Acetic Acid, Gibberellin Acid, and Salicylic Acid) were organized vertically, whereas the application times (one, two, and three times) were organized horizontally. In the two growing seasons, the evaluated growth regulators significantly influenced the number of branches plant^{-1}, 100-seed weight, seed weight plant^{-1}, and seed yield faddan^{-1} characteristics. Plants treated with 200 ppm Gibberellin or Salicylic Acid had the highest mean values of the specified attributes in both seasons. The results also demonstrated that the examined application timings had a highly significant impact on all analyzed features in both seasons. Furthermore, growth regulators were applied three times at 30, 60, and 90 days after sowing (DAS), yielding the greatest average values of seed yield faddan^{-1} (1365.64 and 1373.87 kg in the first and second seasons, respectively).

Keywords: *Faba bean, Growth regulators, Seed yield and its components*

Introduction

Among pulses, Faba bean (*Vicia faba* L.), the first leguminous food crop in Egypt which plays crucial and significant role in the sustainable agriculture. It is grown globally for its high protein content as food for humans, most commonly included in the diets of inhabitants of developing countries in the Mediterranean region, the Middle East, Ethiopia, and China. Faba bean is also used for animal feeding and green manure (Koç *et al.*, 2018; Martineau-Côté *et al.* 2022). Additionally, it has many agronomic advantages, which may incite production growth in the future by its ability to biological N_2 fixation, that wisely used to reduce nitrogen fertilizer applications, and that will lead to decrease diseases, and pests in the soil and increase biodiversity (Köpke and Nemecek, 2010; Hardan and Nasseralla, 2017; Koç *et al.*, 2018).

Received: 22 August 2023/ Accepted: 10 September 2023/ Published online: 1 October 2023

In 2021, Egypt produced about 105051 tons of faba bean resultant from a cultivated area of about 62789.16 feddans (FAOSTAT, 2023). In this regard, Attia *et al.*, (2019) reported that Egypt is the most importing country for beans in the world, because of the huge gap between the local production and consumption of faba bean. Therefore, the Egyptian state encourages the expansion of strategic crops including faba bean to fill the food gap and also to supply hard currency. Abdelaal and Soliman, (2022) also pointed out the self-sufficiency of this crop between 2000 and 2020 was 97.9 and 10.1%, respectively. This huge reduction may due to both the cultivated area and production of Faba bean (Kandil, 2022).

Improvement of the environmental conditions surrounding plants is one of the most crucial factors affecting the high-yield production of faba bean (Patrick and Stoddard, 2010; Hardan and Nasseralla, 2017). Plant growth regulators are one of the key factors for yield improvement in different field crops. Salicylic Acid (SA) is a natural plant hormone and has many important effects on the regulation of plant growth, photosynthesis, metabolic processes, induction of flowering, and other physiological processes (Khan *et al*., 2010; Ahmad *et al*., 2018). SA also plays a significant role during the preliminary stages of Rhizobium-legume symbiosis (Rasmussen *et al*., 1991). In addition, it has been reported that the SA has diverse effects as an important signal molecule on biotic and abiotic stress tolerance like salinity, heat stress, and drought (Khan *et al*., 2010). Increasing salicylic acid from 0 to 70 ppm led to increasing plant height, yield, and yield components such as the number of pods per plant and weight of 100 seeds (Hardan and Nasseralla, 2017).

On other hand, gibberellins (GA) as phytohormones play a role in balancing and regulating the growth of internodes (cell elongation) and the growth (shoot growth), development of the leaves, and are involved in regulating dormancy (Fadhil and Almasoody, 2021). Meanwhile, indole-3-acetic acid (IAA), the main auxin in plants, is produced mainly in the shoot apex bud and young leaves. This hormone has wide range of effects on many physiological processes like cell division vascular, root initiation, tissue differentiation, cell elongation, flowering, fruit setting, ripening, translocation of carbohydrates, and senescence (Venis and Napier, 1997; Awan *et al*., 1999; Wang *et al*., 2001; Al-Whaibi *et al*., 2010; Sadak *et al*., 2013 and Ashraf, 2015). In this context, Fadhil and Almasoody, (2021) found that spraying faba bean plants with gibberellic acid at a concentration of 300 mg l^{-1} resulted in the highest average in number of branches/plant, the number of pods, the number of seeds in the pod, weight of 100 g seed, and seed yield/plant. Awadalla *et al*., (2018) reported high seed yield and quality of faba bean due to applying foliar spraying IAA at level 75 ppm under water deficit conditions.

The objective of the present work was to assess the effect of foliar application of salicylic acid, indole acetic acid and gibberellic acid at different application times on yield and its components of faba bean cultivar “Giza 843”.

Materials and Methods

This study was carried out during the two growing seasons 2020/2021 and 2021/2022 at the Agronomy Experimental Farm, Faculty of Agriculture, Assiut University to study the response of faba bean seed yield and its components to foliar spray by some growth regulators. The soil structure of the experimental site is clay, comprising 42.60% clay, 30.40% silt and 27% sand with pH of 8.02 and EC 0.74 dsm $^{-1}$. This experiment consists of two factors as follows:

1. Foliar application with growth regulators (salicylic acid, Indole acetic acid and gibberellic acid) at 200 ppm in addition to control (distilled water was used as a solvent).

2. Number of application times:

- One time at 30 days after sowing (DAS).
- Two times at 30 and 60 DAS, respectively.
- Three times at 30, 60 and 90 DAS, respectively.

The experiment was carried out in randomized complete block design (RCBD) with three replications utilizing a strip plot configuration. Foliar applications were organized vertically, but application numbers were assigned horizontally. Faba bean cultivar Giza 843 was sowed on October 20th and 25th of each growing season. The experimental unit area was 10.5 m^2 and was made up of 6 rows 3 m long and 60 cm apart, with plant to plant (on the row) intervals of 25 cm. At the time of planting, two or three seeds were dribbled into each hill to promote better emergence and a uniform stand of plants. To eliminate weeds from the experimental plots, hoeing was done twice during the growing season. Maize was the preceding summer crop in both seasons. All other suggested faba bean crop cultural techniques were carried out in both seasons. All foliar sprays were carried out after daybreak using a 5-liter pressure garden sprayer at a rate of 200 liters/fed.

Measurement traits

At harvest, the average number of pods per plant, 100-seed weight (g), and seed weight plant $^{-1}$ (g) were calculated for ten guarded plants that were randomly selected from the middle rows of each experimental unit. Each experimental unit's whole plant population was also collected, air dried, and threshed before being weighed and converted to a seed yield measurement in kilograms (kg).

Statistical Analysis

Data were statistically evaluated using the computer program "SAS" in accordance with Gomez and Gomez's (1984) publication on the analysis of variance (ANOVA). Snedecor and Cochran's (1980) revised Least Significant Difference (RLSD) approach was applied to test for differences between treatment means at the 5% level of probability.

Results and Discussion

A-Number of pods plant

The findings in Table 1 demonstrate that the tested growth regulators significantly affected the quantity of faba bean pods on plant^{-1} throughout the course of two growing seasons. In this way, the faba bean plants that were sprayed with salicylic acid (SA) at a rate of 200 ppm outperformed the other spray treatments with other growth regulators and obtained the highest mean values in this regard (17.24 and 17.48 pod/plant in the two respective seasons). These plants were then followed by those that were sprayed with gibberellic acid (GA) at a rate of 200 ppm, but there was no discernible difference between them (17.13 and 17 pods plant^{-1}). Conversely, control plants provided the lowest average values for the number of pods per plant. (12.74 and 12.60 pods plant^{-1} in the two respective seasons). The role of SA and GA in numerous metabolically and physiologically significant plant processes, such as flowering, stomatal closure, thermogenesis,3 osmolyte metabolism, photosynthesis, fruit quality improvement, water balances, and antioxidant defense systems, as well as SA's ability to improve biological, physiological, and morphological indexes in plants as well as yield components, can be used to explain the previous findings. Al-Hilfy *et al*. (2017) noted a comparable trend.

Table 1. Means of pods number plant^{-1} of faba bean as affected by growth regulators, application times and their interaction in 2020/2021 and 2021/2022 seasons

Seasons	2020/2021				2021/2022			
Spray number (S) / Growth regulators (G)	One time spray	Two times spray	Three times spray	**Mean**	One time spray	Two times spray	Three times spray	**Mean**
Control	11.92	12.73	13.56	**12.74**	12.22	12.59	13.00	**12.60**
Gibberellic acid	15.57	17.13	18.68	**17.13**	15.67	17.11	18.72	**17.17**
Indole-3-acetic acid	13.98	14.28	14.83	**14.37**	13.73	14.08	14.87	**14.23**
Salicylic acid	16.08	17.38	18.27	**17.24**	15.40	17.33	19.71	**17.48**
Mean	**14.39**	**15.38**	**16.34**	**---**	**14.25**	**15.28**	**16.58**	**---**
F test and R.l.S.D		F	R.L.S.D			F	R.L.S.D	
Growth regulators (G)		**	0.40			**	0.53	
Spray number (S)		**	0.33			**	0.26	
G × S		**	0.45			**	0.62	

Where ** mean significant at 1 % level of probability

B-Seed index (g)

Additionally, the quantity of pods produced by faba bean plants throughout the two growing seasons was significantly influenced by the growth regulators' application times (Table 1). Growth regulators applied three times at 30, 60, and 90 days after sowing (DAS) produced the highest mean values of pods per plant

(14.39 and 14.25 in the first and second seasons, respectively), followed by applications made twice at 30 and 60 DAS (15.38 and 15.28 pods plant^{-1} in the first and second seasons, respectively).

Here again, the quantity of pods plant^{-1} in both seasons was significantly impacted by the interplay between growth regulators and treatment periods (Table 1). Thus, in the first season, faba bean plants sprayed with salicylic acid three times at 30, 60, and 90 DAS followed by plants sprayed with gibberellic acid three times at 30, 60, and 90 DAS recorded the highest average values of pods number plant^{-1} (18.68), with no discernible difference between the two. The second season compounding value of 19.71 from faba bean plants that received salicylic acid spraying three times at 30, 60, and 90 DAS was also noted.

The findings shown in Table 2 highlight the fact that the evaluated growth regulators significantly affected the weight of 100 faba bean seeds over the course of two growing seasons. As a result, the faba bean plants exposed to gibberellic acid at a rate of 200 ppm outperformed other spray treatments using other growth regulators and obtained the highest mean values in this regard (85.97 and 81.18 in the two different seasons), with no discernible differences between gibberellic acid and salicylic acid in the second season, which provided 81.16 g for every 100 seed weight.

The preceding findings might be explained by the roles of SA and GA in several physiological and metabolically significant plant activities, such as photosynthesis and the shift of metabolism from source to sink, which increases grain weight. Al-Hilfy *et al*. (2017) noted a comparable trend.

Furthermore, it is evident from the data in the preceding table that growth regulator application timing had a highly substantial impact on the faba bean 100 seed weight throughout the course of the two growing seasons (Table 2). The highest average values of the seed index trait were obtained by applying growth regulators three times at 30, 60, and 90 days after sowing (DAS). In contrast, the lowest mean values in this regard were obtained by applying growth regulators only once at 30 DAS (77.07 and 75.55 g in the two respective seasons).

This may be due to the increase in the number of additions to growth regulators for bean plants at different times, which led to their availability for a long time and increased their efficiency to carry out their various functions, such as increasing the rate of photosynthesis and transporting the nutrients formed from it from the leaves (sources) to the seeds (sinks), and thus increasing the weight of the seeds.

Regarding the interaction effect in this regard, Table 2's data show that only the first season's differences on the seed index trait were significant at the 5% level of probability, whereas the interaction between growth regulators and application times was not. Thus, the largest average values of the seed index characteristic (90.52 g) were reported in the first season by faba bean plants that received three sprays of gibberellic acid at 30, 60, and 90 DAS.

On the other hand, the lightest weight of bean seeds was detected from bean plants that were sprayed with distilled water, i.e., from the control treatment (without growth regulators) once 69.80 g in the first season.

Table 2. The means of faba bean 100 seed weight (g) as influenced by growth regulators, application periods, and their interaction in the seasons of 2020–2021 and 2021–2022

Seasons	**2020/2021**				**2021/2022**			
Spray number / Growth regulators	One time spray	Two times spray	Three times spray	**Mean**	One time spray	Two times spray	Three times spray	**Mean**
Control	69.80	73.30	75.44	**72.85**	69.47	72.17	72.67	**71.44**
Gibberellic acid	82.01	85.39	90.52	**85.97**	78.83	79.97	84.73	**81.18**
Indole-3-acetic acid	76.53	78.08	80.22	**78.28**	74.93	76.63	78.00	**76.52**
Salicylic acid	79.95	82.24	85.65	**82.61**	78.97	80.03	84.47	**81.16**
Mean	**77.07**	**79.75**	**82.96**	**----**	**75.55**	**77.20**	**79.97**	**---**
F test and R.l.S.D		F	R.L.S.D			F	R.L.S.D	
Growth regulators (G)		**	0.67			**	1.05	
Spray number (S)		**	0.63			**	0.96	
G × S		**	1.31			NS	--	

Where NS and ** stand for non-significant and significant, respectively, at the 1% level of probability.

The data in Table 3 demonstrate that over the two growing seasons, seed weight plant^{-1} of the faba bean was significantly affected by the growth regulators that were evaluated. The largest mean values in this regard were found in faba bean plants that were sprayed with salicylic acid or gibberellic acid in both seasons. As a result, the application of any growth regulators to faba bean plants at a rate of 200 ppm outperformed the control treated plants. Since the number of plant^{-1} pods and 100 seed weight characteristics, which were thought to be the key contributors to the seed weight plant^{-1} trait, showed the same trend, this seems logical. These results are consistent with what Al-Hilfy et al. (2017) found.

From the data shown in the same previous table, it is evident that growth regulator application time treatments had a highly substantial impact on the faba bean plant^{-1} Plant^{-1}'s seed weight throughout the course of the two growing seasons (Table 3). The highest average seed weight plant^{-1} values were obtained by applying growth regulators three times at 30, 60, and 90 days after sowing (DAS). In contrast, the lowest mean values in this regard were obtained by applying growth regulators only once at 30 DAS (39.71 and 38.30 g in the two corresponding seasons).

This may be due to the increase in the number of additions to growth regulators for bean plants at different times, which led to their availability for a long time and increased their efficiency to carry out their various functions, such as increasing the rate of photosynthesis and transporting the nutrients formed from the leaves (sources) to the seeds (sinks), and thus increasing the weight of the seeds and consequently increased the weight of seeds plant^{-1}.

Regarding the interaction effect in this regard, Table 3's data show that only the first season's differences in the seed weight plant^{-1} were significant at the 5% level of probability, whereas the interactions between growth regulators and application times were not. As a result, in the first season, faba bean plants treated with three applications of gibberellic acid at 30, 60, and 90 DAS recorded the highest average values of seed weight plant^{-1} (52.92 g), with no discernible difference between those treated with three applications of salicylic acid (52.47 g). On the other hand, bean plants that received a single spray of distilled water, or the control treatment (without growth regulators), had the least weight of bean seeds plant^{-1} (32.04 g in the first season). This is to be expected given that the seed index characteristic showed the same interaction and trend.

Table 3. The means of faba bean seeds per plant (g) as influenced by growth regulators, application periods, and their interaction in the seasons of 2020–2021 and 2021–2022

Seasons	2020/2021				2021/2022			
Spray number / Growth regulators	One time spray	Two times spray	Three times spray	**Mean**	One time spray	Two times spray	Three times spray	**Mean**
Control	32.04	34.18	35.93	**34.05**	27.81	31.89	33.77	**31.16**
Gibberellic acid	44.81	48.41	52.92	**48.71**	43.06	47.78	54.53	**48.46**
Indole-3-acetic acid	37.77	40.02	40.77	**39.52**	36.77	40.67	42.30	**39.92**
Salicylic acid	44.20	47.24	52.47	**47.97**	45.58	48.44	52.58	**48.87**
Mean	**39.71**	**42.46**	**45.52**	**--**	**38.30**	**42.20**	**45.80**	**--**
F test and R.l.S.D		F	R.L.S.D			F	R.L.S.D	
Growth regulators (G)		**	1.57			**	1.68	
Spray number (S)		**	2.07			**	1.26	
G × S		**	1.68			NS	_--_	

Where NS and ** mean non-significant and significant at 1 % level of probability, respectively.

The presented data in Table 4 reveal that the tested growth regulators had a highly significant effect (P≤ 0.01) on seed yield feddan^{-1} of faba bean in the two growing seasons. Thus, the application of any growth regulators to faba bean plants at the rate of 200 ppm surpassed the control treated plants. Furthermore, the maximum mean values of seed yield faddan^{-1} were detected from faba bean plants which were sprayed by gibberellic or salicylic acid in both seasons. This is to be expected since the same trend was observed with regard to seed weight plant^{-1} trait which considered the main contribution for seed yield faddan^{-1} trait. These findings are in a good line with those observed by Al-Hilfy et al. (2017).

Furthermore, the information shown in the same previous table makes it abundantly evident that the application timing of growth regulators had a highly substantial impact on the faba bean seed yield faddan^{-1} in the two growing seasons (Table 4). The greatest average values of faddan^{-1}trait seed yield were obtained by applying growth regulators three times at 30, 60, and 90 days after sowing (DAS) (1365.64 and 1373.87 kg in the first and second seasons, respectively).

Table 4. Means of seeds yield per faddan (kg) of faba bean as affected by growth regulators, application times and their interaction in 2020/2021 and 2021/2022 seasons

Seasons	**2020/2021**				**2021/2022**			
Spray number / Growth regulators	One time spray	Two times spray	Three times spray	**Mean**	One time spray	Two times spray	Three times spray	**Mean**
Control	961.31	1025.31	1077.91	**1021.51**	834.24	956.82	1013.21	**934.76**
Gibberellic acid	1344.42	1452.27	1587.59	**1461.43**	1291.74	1433.26	1635.97	**1453.66**
Indole-3-acetic acid	1133.24	1200.74	1222.95	**1185.64**	1103.18	1220.17	1269.02	**1197.46**
Salicylic acid	1325.87	1417.23	1574.10	**1439.07**	1367.41	1453.26	1577.28	**1465.98**
Mean	**1191.21**	**1273.89**	**1365.64**	**--**	**1149.15**	**1265.88**	**1373.87**	**--**
		F	R.L.S.D			F	R.L.S.D	
F test and R.l.S.D		**	47.26			**	50.65	
Growth regulators (G)		**	62.19			**	37.86	
Spray number (S)		**	50.4			NS	_--_	

Where NS and ** stand for non-significant and significant, respectively, at the 1% level of probability.

Otherwise, growth regulators were sprayed once at 30 DAS, which resulted in the lowest mean values of seed yield faddan^{-1} (1191.22 and 1119.15 kg for the two corresponding seasons). This makes sense because the seed yield plant^{-1} characteristic showed the similar pattern. Regarding the interaction effect in this regard, Table 4's data make clear that only the first season's differences in the seed index trait were significant at the 5% level of probability, whereas the interaction between growth regulators and application times was not. Therefore, in the first season, faba bean plants that received three applications of gibberellic acid at 30, 60, and 90 DAS recorded the highest average values of seed yield faddan^{-1}trait (1587.59k g), with no discernible difference from faba bean plants that received three applications of salicylic acid (1547.10 kg).

On the other hand, the control treatment (without growth regulators) had the lowest seed yield mean value (961.31k g in the first season) when faba bean plants were sprayed with distilled water. Given that the same interaction and similar trend were seen in relation to seed weight plant^{-1}, this is to be expected.

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استجابة محصول البذور ومكوناته في الفول البلدي للرش الورقي ببعض منظمات النمو

المهدي عبد المطلب طعيمة، عادل محمد محمود، السعدي عبد الحميد علي، رضا ابو المحاسن

قسم المحاصيل، كلية الزراعة، جامعة اسيوط، مصر.

الملخص

أجريت هذه الدراسة خلال موسمي الزراعة 2021/2020 و2022/2021 في مزرعة قسم المحاصيل بكلية الزراعة جامعة أسيوط لدراسة مدى استجابة محصول الفول ومكوناته للرش الورقي ببعض منظمات النمو. نفذت التجربة بتصميم القطاعات العشوائية الكاملة (RCBD) باستخدام الشرائح المنشقة بثلاثة مكررات. تم ترتيب الرش الورقية (كنترول، اندول حمض الخليك، وحمض الجبريليك وحمض الساليسيليك) رأسيا، بينما تم تخصيص عدد مرات الرش (مرة واحدة، مرتين، ثلاث مرات) أفقيًا. أوضحت النتائج المتحصل عليها أن منظمات النمو المختبرة كان لها تأثير معنوي كبير على عدد القرون للنبات ووزن المائة بذرة ووزن البذور للنبات ومحصول البذور للفدان في موسمي الزراعة. كما أعطت نباتات الفول التي تم رشها بـ 200 جزء في المليون حمض جبريليك أو حمض الساليسيليك أعلى متوسط قيم للصفات المذكورة في كلا الموسمين. كما أظهرت النتائج التي تم الحصول عليها أن عدد مرات الرش كان له تأثير عالي المعنوية على جميع الصفات المدروسة في كلا الموسمين. علاوة على ذلك، فإن استخدام منظمات النمو ثلاث مرات في 30 و60 و90 يوم من الزراعة أعطى أعلى متوسط قيم لمحصول البذور للفدان (1365.64 و1373.87 كجم في الموسمين الأول والثاني على التوالي).