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Effect of garlic extract, ascorbic acid and nicotinamide on growth, some biochemical aspects, yield and its components of three faba bean (*Vicia faba* L.) cultivars under sandy soil conditions

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Abstract

Background: Garlic extract is a highly nutritive value extract; it contains large number of important enzymes and more than 200 biochemical compounds such as antioxidants and vitamins. Ascorbic acid and nicotinamide are considered as antioxidants and also known as growth-regulating compounds that influence different physiological and biochemical processes in plants.

Methodology: A field experiment was conducted in sandy soil during two successive seasons of 2015/2016 and 2016/2017 at Research and Production Station, National Research Centre, El-Nubaria Province, El-Behera Governorate, Egypt. The objective of this investigation was to study the effect of foliar application of garlic extract (5%), ascorbic acid (200 ppm) and nicotinamide (50 ppm) compared with tap water on growth, some biochemical aspects, yield, yield components and some chemical components of three faba bean cultivars (*Vicia faba* L, cv., Nubaria-1, Nubaria-2 and Giza-843).

Results: The obtained results showed that Nubaria-1 was superior to Nubaria-2 and Giza-843 in all growth and yield criteria in the growing seasons except plant height was superior in Nubaria-2. Foliar treatment of garlic extract had the superiority effect in all characters of growth and yield and its components, and consequently increased significantly all yield criteria of Nubaria-1 cultivar. Data clearly showed that the effect of different treatments caused marked increases in photosynthetic pigments, indole acetic acid, phenolics, carbohydrate constituents, free amino acids and proline contents of Nubaria 1 cultivar which was sprayed by garlic extract at 5% followed by nicotinamide and ascorbic acid, respectively.

Conclusions: In general, the current research suggested that garlic extract at 5% as a foliar application increased the quantity of faba bean cultivars grown under sandy soil conditions. Therefore, garlic extract at the rate of 5% and Nubaria1 encourage the farmers to use of garlic extract to give promising seed yield under reclaimed sandy soil.

Keywords: Faba bean, Cultivars, Garlic extract, Ascorbic acid, Nicotinamide, Yield and yield components

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Introduction

Faba bean (*Vicia faba* L.) is the fourth most important leguminous crop in the world. It is one of the most important food crop for human and animal feed (pigs, horses, poultry and pigeons) (Singh and Bhatt, 2012). Seeds of faba bean contain about 58% carbohydrate, 26% protein, 2% fat, some vitamins (vitamin B1, vitamin B2, vitamin B3, vitamin B6, vitamin B9, vitamin C and vitamin K) and some minerals (calcium, copper, iron, manganese, magnesium, potassium, selenium, sodium and zinc) (Alghamdi, 2009). So, it is a common breakfast food in Egypt and the best crop which can be used as a green manure and also one of the best bio factory of nitrogen by fixing 130 to 160 kg N/ha (Hoffmann *et al.,* 2007). Moreover, it is a good source of lysine-rich protein and good source of *levadopa* (*L-dopa*) a precursor of dopamine, and it can be potentially used as medicine for the treatment of Parkinson's disease (Singh *et al*., 2013). Increasing faba bean yield per unit area can be achieved by breeding high yielding cultivars. Significant differences in faba bean cultivars have been shown by many workers (Osman *et al.,* 2010, Bakry *et al.,* 2011 and Khattab *et al*., 2015). In Egypt, Abou-El-Seba et al. (2016) stated that faba bean cultivars showed highly significant variation of plant height, weight and number of pods/plant, 100-seed weight, seed yield/plant and seed yield. In Baltic, Pluduma–Paunina et al. (2018) concluded that faba bean yield has been significantly affected by varieties.

Cultivation of faba bean in newly reclaimed sandy soil suffers from reduction of productivity due to low water, salinity water and soil, nutrient deprivation and temperature fluctuations .Therefore, we can use some ingredients or natural extracts and antioxidants to avoid those problems and increase plant tolerance to these adverse environmental conditions.

Garlic (*Allium sativum*) is a highly nutritive value extract; it contains large number of important enzymes and more than 200 biochemical compounds such as antioxidants and vitamins (Mohamed It contains high contents of volatile and sulphur compounds such as aliin, allicin, ajoene, allylpropyl, diallyl, trisulfide, sallylcysteine, vinyldithiines, sallylmercaptocystein and others (Mohamed and Akladious, 2014 and El-Saadony *et al.,* 2017). In addition, garlic is considered as a source of vitamins (especially vitamin B complex and vitamin C), antioxidants, flavonoids and minerals (especially P, K and Se) (Pekowska and Skupień, 2009), being even considered a rich source of other non-volatile phytonutrients with important medicinal and therapeutic properties, from which a particular emphasis is given to flavonoids, saponins and sapogenins, phenolic compounds, nitrogen oxides, amides and proteins (Lanzotti *et al.*, 2014).

Ascorbic acid (vitamin C) is one of those antioxidants. Ascorbic acid is an abundant molecule in garlic plants. It has also been shown to play multiple roles in plant growth such as in cell division, cell wall expansion and other developmental processes (El-khayate *et al.,* 2015). It also acts as an antioxidant as it detoxifies H_2O_2 which is formed by the dismutation of O^{-2} (Kasim Wedad *et al.,* 2017).

Nicotinamide is known as a growth-regulating factor that influences many physiological processes such as biosynthesis of enzymes, nucleic acids and proteins and acts as a coenzyme (Hathout, 1995). Nicotinamide (vitamin B3/niacin) is a water-soluble vitamin and a well-characterized constituent of the pyridine dinucleotide coenzymes NADH and NADPH, which are involved in many enzymatic oxidations−−reduction reactions in living cell (Sadak *et al.,*2010). Abdel-hamid et al. (2013) showed that there is a significant improvement of physiological and biochemical parameters as well as concentrations of soluble sugars, proline, amino acids and total *N* and other mineral contents of faba bean plants by nicotinamide. Recently, Sadak (2016) reported that growth, yield components, indole acetic acid (IAA), photosynthetic pigments, total soluble sugars (TSS), free amino acids, proline and phenolic contents are significantly increased by soaking of *Pisum sativum* L. seeds with nicotinamide at the two dates of sowing. Moreover, Dawood et al. (2019) concluded that nicotinamide and/or humic acid had a positive effect on growth parameters, photosynthetic pigments, seed yield, and yield components as well as some biochemical constituents of the yielded faba bean seeds.

Therefore, the objective of this study was to compare the effect some foliar application with garlic extract, ascorbic acid and nicotinamide on growth, photosynthetic pigments content, yield and yield components and some chemicals components of three faba bean cultivars.

Materials and methods

Plant materials and experimental conditions

Two field experiments were conducted at Research and Production Station, National Research Centre, El-Nubaria Province, El-Behera Governorate, Egypt, during two successive winter seasons of 2015/2016 and 2016/2017 to study the effect of foliar application of garlic extract, ascorbic acid, nicotinamide and tap water (control) on growth, some chemical constituents, yield and yield components of three faba bean cultivars.

The experiment was arranged in split plot design with three replications where the faba bean cultivars (Nubaria-1)V1), Nubaria-2 (V2) and Giza-843 (V3)) occupied the main plots, while sub-plots were devoted to foliar application of (garlic extract (P1), ascorbic acid (P2), nicotinamide (P3) and tap water (P0, control))

randomly in the subplots. The seeds of faba bean cultivars were obtained from Field Crops Research Institute, Agricultural Research Center, Giza. Seeds were planted on November 17 and 20 in the first and second seasons, respectively. Foliar treatments were sprayed on plant foliage twice during plant growth period at 30 and 45 days after sowing. Some mechanical and chemical analysis of soil samples at 30 cm depth in experimental sites before soil preparation was determined according to Chapman and Pratt (1978). These analyses are presented in Table 1.

Irrigation was carried out using the modern sprinkler irrigation system where water was added every 5 days. Nitrogen fertilizer as ammonium nitrate (33.5%) was added at the rate of (50 kg N/fed.), while phosphorus fertilizer was applied in the form of calcium super phosphate (15% P_2O_5) at the rate of 200 kg/fed and potassium fertilizer was added in the form of potassium sulphate (48% K_2O) at the rate of 48 kg/fed at seedbed preparation. The normal agronomic practices of growing faba bean were practised till harvest as recommended by Legumes Research Dept. A.R.C., Giza.

Garlic extract (5%): newly produced garlic cloves were brought. Two hundred fifty grams of these cloves was put in a glass beaker that contains 250 ml of tap water. The beaker was put in a freezer for 1 day to freeze, and then the beaker was taken out of the freezer and left it to thaw. Freezing and thawing were repeated three times. Water was added to a final volume of 1 l before filtering. The final volume of the filtrate was adjusted to 1: l before being used (Hanafy *et al.* 2012). Ascorbic acid 200 ppm and nicotinamide 50 ppm were used.

Data recorded

After 60 days from sowing, ten randomized plants were selected from each plot to determine the growth parameters plant height (cm), number of branch/plant, number of leaves/plant and leaf area (cm^2) average area of all leaves on a plant. At harvest time, a random sample of ten plants was taken from each plot to determine plant height (cm), weight of plant(g), number of pods/plants, seed yield/plant and 100-seed weight (g). Seed yield "kilogram/hectare" was collected from the whole plot and then converted into yield per hectare. 1 ha = 10,000/4200 and fed = (2.38095 fed).

Chemical analysis

Total chlorophyll a and b contents in fresh leaves were estimated using the method of Lichtenthaler and Buschmann (2001). Indole acetic acid content was extracted and analysed by the method of Larsen et al. (1962). Phenolic content was measured as described by Danil and George (1972). Total carbohydrates were determined using phenol-sulphoric acid method as described by Dubois et al. (1956). Total soluble sugars (TSS) were extracted according to Homme et al. (1992). Polysaccarides were calculated by subtracting total soluble sugars from total carbohydrates. Free amino acid and proline were extracted according to (Vartainan et al. (1992), free amino acids were determined with the ninhydrin reagent method (Yemm and Cocking, 1955) and proline content was determined according to Bates et al. (1973).

Statistical analysis

Analysis of variance technique of MSTATC was used to test the degree of variability between the obtained data. Least significant difference (LSD at 5%) was used for the comparison between treatment means (Gomez and Gomez, 1984).

Results

Growth parameters

Data in Table 2 show that faba bean cultivars significantly differed in their plant height (cm), number of branches/plant, number of leaves/plant and leaf area (cm^2) at 60 days after sowing. Nubaria-1 cultivar gives the highest values in all growth parameters compared with the other two cultivars.

Different foliar applications (garlic extract, ascorbic acid and nicotinamide) caused marked and significant increases in all growth parameters as compared with untreated control (P0). Foliar application of Garlic extract caused the highest significant increases of plant height (cm) and leaf area (LA) (cm^2). Meanwhile, foliar application of ascorbic acid gave the highest significant increase of number of branches and number of leaves/plant.

Yield and its components

Data presented in Table 3 show the effect of cultivars, foliar applications and their interactions on yield and its

Table 1 Mechanical and chemical analysis of the experimental soil

a. Mechanical analysis									
Sand %	Silt %	Clay %	Texture	Organic matter %		pH	EC (mhos/cm)		$CaCO_3$%
90.80	4.00	5.20	Sandy soil	0.24		8.66	0.11		5.20
b. Chemical analysis									
Macronutrients (mg/100 g)						Micronutrients (ppm)			
N	P	K	Ca	Mg	NNa	Fe	Zn	Mn	Cu
4.20	0.12	9.22	80.00	18.20	13.18	8.15	9.12	0.10	0.20

Table 2 Effect of cultivars, foliar application of garlic extract, ascorbic acid or nicotinamide and interactions on growth parameters of faba bean plants (data are means of two seasons)

Treatments	Characters	Plant height (cm)	Number of branches/ plant	Number of leaves/ plant	LA (cm^2)
Cultivars					
	V1	103.56	2.05	41.79	16.17
	V2	99.75	1.86	40.59	14.77
	V3	92.75	1.58	34.23	13.36
	LSD at 5%	4.05	0.47	2.34	0.92
Foliar application					
	P0	89.83	1.54	30.56	12.77
	P1	111.25	1.78	41.97	16.15
	P2	94.50	2.12	42.79	14.27
	P3	99.17	1.88	40.17	16.08
	LSD at 5%	3.19	0.19	3.02	0.99
V1	P0	95.00	1.85	31.33	14.30
	P1	113.75	2.50	54.33	18.18
	P2	102.50	1.85	33.5	14.41
	P3	103.00	2.00	48.00	17.78
V2	P0	88.00	1.19	31.00	12.40
	P1	119.50	1.25	35.00	15.02
	P2	90.00	3.00	53.87	14.41
	P3	101.50	2.00	42.50	17.23
V3	P0	86.50	1.58	29.33	11.62
	P1	100.50	1.60	36.57	14.92
	P2	91.00	1.50	41.00	14.00
	P3	93.00	1.65	30.00	12.90
LSD at 5%		5.53	0.33	5.23	1.67

P0 = spraying with tap water, P1 = foliar application with garlic extract at (5%), P2 = foliar application with ascorbic acid at 200 ppm and P1 = foliar application with nicotinamide at 50 ppm

components of faba bean plants. Results indicated that yield and its components were significantly affected by cultivars. Nubaria-1 cultivar significantly exceeded Nubaria-2 and Giza-843 cultivars in plant height (cm), weight of plant (g), number of pods per plant, seed yield per plant (g), weight of 100 seeds (g) and seed yield (kg/hectare.)

Yield and its components are significantly affected by the foliar applications with garlic extract, ascorbic acid and nicotinamide. Foliar application of garlic extract was more effective in increasing plant height weight of plant (g), number of pods per plant, seed yield/plant (g), 100-seed weight (g) and seed yield (kg/hectare) compared with other treatments.

Data presented in Table 3 clearly show that no significant differences on yield and its components of faba bean plant except on the number of pods per plant, seed yield/plant (g) and seed yield (kg/hectare). Nubaria-1 cultivar treated with garlic extract gave the highest values of plant height (cm), weight of plant (g), number of pods per plant and 100-seed weight (g), meanwhile Giza-843 cultivar treated with tap water gave the lowest values of the same previous characters.

Table 3 Effect of cultivars, foliar application of garlic extract, ascorbic acid or nicotinamide and interactions on yield and its components of faba bean plants (data are means of two seasons)

Treatments	Characters	Plant height (cm)	Weight of plant (g)	Number of pods/ plant	Seed yield/ plant (g)	100 seeds (g)	Seed yield (kg/ha)
Cultivars							
	V1	105.53	61.52	14.45	48.52	75.12	1133.76
	V2	103.02	59.59	13.48	46.58	73.28	1104.67
	V3	100.29	59.61	10.27	38.91	64.27	924.98
	LSD at 5%	2.05	1.13	0.24	0.65	0.43	105.32
Foliar application							
	P0	101.49	59.54	12.47	43.45	70.23	800.93
	P1	104.12	61.47	13.06	46.23	71.87	1184.00
	P2	102.87	59.84	12.74	44.55	70.57	1108.64
	P3	103.30	60.11	12.66	44.45	70.90	1124.33
	LSD at 5%	1.35	0.47	0.32	0.40	0.45	145.24
Interactions							
V1	P0	104.51	60.76	14.24	47.16	74.57	645.26
	P1	106.97	62.98	14.80	49.96	76.23	1437.71
	P2	105.20	60.83	14.47	48.05	74.57	1104.55
	P3	105.43	61.50	14.30	48.92	75.10	1232.95
V2	P0	102.37	59.00	13.24	45.92	72.76	965.14
	P1	104.08	60.63	13.72	47.72	73.68	1296.50
	P2	103.10	59.58	13.54	46.73	73.25	1103.02
	P3	102.53	59.13	13.40	45.93	73.43	1170.33
V3	P0	97.60	58.87	9.94	37.28	63.36	654.48
	P1	101.32	60.78	10.66	41.00	65.68	1148.69
	P2	100.30	59.10	10.20	38.87	63.88	924.88
	P3	101.93	59.70	10.27	38.50	64.17	971.88
	LSD at 5%	NS	NS	0.56	0.70	NS	154.00

P0 = spraying with tap water, P1 = foliar application with garlic extract at (5%), P2 = foliar application with ascorbic acid at 200 ppm and P1 = foliar application with nicotinamide at 50 ppm

Photosynthetic pigments content and some physiological aspects of faba bean

Data presented in Table 4 show that there are no significant differences between the tested faba bean cultivars in their *Chlo* a, *Chlo* b and total pigments. Foliar applications of garlic extract, ascorbic acid or nicotinamide

Table 4 Effect of cultivars, foliar application of garlic extract, ascorbic acid or nicotinamide and interactions on photosynthetic pigments, IAA and phenolic contents of faba bean

Treatments		*Chlo*-a	*Chlo*-b	Total pigments	IAA	Phenolics
Characters		µg/g F wt			µg/g F wt	mg/100 g
Cultivars						
V1		15.98	5.68	23.85	47.46	57.58
V2		16.71	6.25	25.32	66.86	54.55
V3		22.18	8.15	35.53	57.95	52.47
LSD at 5%		NS	NS	NS	NS	NS
Foliar application						
P0		15.09	5.84	23.12	44.09	40.98
P1		20.51	7.41	33.56	60.75	53.93
P2		18.97	6.84	28.43	61.79	61.13
P3		18.59	6.68	27.82	63.08	63.42
LSD at 5%		1.12	0.40	0.70	0.37	0.32
Interactions						
	P0	13.28	4.81	19.92	35.39	42.59
V1	P1	17.68	5.79	25.75	48.64	58.39
	P2	18.22	6.45	27.15	53.06	63.49
	P3	14.75	5.68	22.56	52.77	65.85
	P0	14.39	5.64	22.14	53.33	41.49
V2	P1	17.63	6.75	26.91	69.91	53.91
	P2	16.12	6.01	24.4	70.83	59.74
	P3	18.69	6.61	27.84	73.39	63.05
	P0	17.6	7.08	27.3	43.39	38.86
V3	P1	26.21	9.64	48.01	63.7	49.49
	P2	22.59	8.07	33.75	61.48	60.18
	P3	22.32	7.75	33.07	63.08	61.36
	LSD at 5%	1.94	0.74	1.4	0.64	0.56

P0 = spraying with tap water, P1 = foliar application with garlic extract at (5%), P2 = foliar application with ascorbic acid at 200 ppm and P1 = foliar application with nicotinamide at 50 ppm

caused significant increases in chlorophyll *a*, chlorophyll *b* and consequently total pigments compared with control plants. The best appropriate treatment was garlic extract followed by nicotinamide and ascorbic acid, respectively, compared with untreated control. The highest value of chlorophyll *a*, chlorophyll *b* and total pigments (26.21, 9.64 and 48.01, respectively) were obtained by garlic extract treatment of Giza-843 cultivar compared with the other two cultivars.

Table 4 showed that there was no significant difference between cultivars on indole acetic acid and phenolic contents, while foliar spraying with different compounds caused marked increases in indole acetic acid and phenolic contents. Moreover, data indicated that nicotinamide treatment was more effective than other treatments. The interaction between cultivars and the foliar application was significantly effective on the same behaviours. Nubaria-2 cultivar treated with nicotinamide gave the most positive effect on indole acetic acid than the other interactions, while Nubaria-1 cultivar treated with nicotinamide gave the highest value of phenolic contents.

Table 5 shows that significant differences were observed among cultivars under the study in total carbohydrate%, total soluble sugars, polysaccharides%, free amino acids and proline contents of faba bean plants. Nubaria-1 cultivar gave the highest contents of total carbohydrates% and polysaccharides%, while Nubaria-2 cultivar recorded the highest value of total soluble sugars and free amino acids. In respect to proline, Giza-843 cultivar was superior on other cultivars in proline value.

Table 5 Effect of cultivars, foliar application of garlic extract, ascorbic acid or nicotinamide and interactions on carbohydrate constituents, free amino acids and proline contents of faba bean plant

Treatments		Total CHO%	TSS%	Ploysaccharides %	Free amino	Proline
					mg/100 g dry wt	
Characters						
Cultivars						
V1		20.39	2.12	18.26	266.52	38.32
V2		18.54	2.60	15.94	343.19	51.21
V3		19.98	2.32	17.66	302.10	52.67
LSD at 5%		0.14	0.05	0.17	1.18	0.66
Foliar application						
P0		18.67	2.05	16.62	274.78	38.92
P1		19.66	2.23	17.44	306.21	45.56
P2		20.11	2.35	17.76	317.69	56.84
P3		20.10	2.75	17.35	317.07	54.28
LSD at 5%		0.10	0.05	0.09	1.30	0.46
Interactions						
	P0	19.39	1.91	17.48	227.5	30.99
V1	P1	20.55	2.08	18.47	276.91	35.76
	P2	20.79	2.12	18.67	288.39	39.69
	P3	20.82	2.39	18.43	273.28	46.82
	P0	17.76	2.35	15.41	320.74	42.15
V2	P1	18.70	2.42	16.29	343.02	49.37
	P2	18.85	2.67	16.17	351.79	54.07
	P3	18.86	2.95	15.91	357.22	59.25
	P0	18.86	1.91	16.95	276.11	43.6
V3	P1	19.74	2.18	17.55	298.71	51.55
	P2	20.70	2.26	18.44	312.88	58.75
	P3	20.62	2.91	17.71	320.72	56.78
	LSD at 5%	0.17	0.08	0.15	2.26	0.79

Foliar application of garlic extract, ascorbic acid or nicotinamide caused significant increases in total carbohydrates%, total soluble sugars (TSS), polysaccharides%, free amino acids and proline of faba bean plants. Spraying with ascorbic acid gave the best values in previous characters except for total soluble sugars.

P0 = spraying with tap water, P1 = foliar application with garlic extract at (5%), P2 = foliar application with ascorbic acid at 200 ppm and P1 = foliar application with nicotinamide at 50 ppm

Discussion

Effect of cultivars

The obtained data showed the significant effect of cultivars on different growth parameters (Table 2), yield and yield components of faba bean plant (Table 3), photosynthetic pigments (*Chlo* a, *Chlo* b and total pigments), indole acetic acid (IAA), phenolic contents (Table 4), carbohydrate fractions, free amino acids and proline (Table 5). Nubaria-1 cultivar gave the highest values in all growth and yield parameters compared with the other two cultivars. The superiority of Nubaria-1 cultivar for yield and its components might be due to the highest values of photosynthetic pigments. These increases might be due to the increased rate of quenching of chlorophyll fluorescence, which markedly increased plant biomass, and this steady state was greater than the other two cultivars. Moreover, the superiority of this cultivar might be due to the superiority in plant height, weight of plant, number of pods/plant, seed yield/plant and seed yield/hectare. These obtained results are in conformity with those obtained earlier (Osman *et al.*,2010, Bakry *et al.* 2011 , Khattab *et al.*, 2015 and Abou-El-Seba *et al.* 2016), and they showed that faba bean cultivars varied significantly on plant height, weight/plant (g), number of pods/plant, 100-seed weight (g), seed yield/plant and seed yield (kg/hectare) during the two growing seasons. Also, Bakhoum et al. (2019), Dawood et al. (2019) and El-Bassiouny et al. (2020) confirmed this result on soybean, flax and wheat plants. These differences in morphological characters especially plant height among cultivars of faba bean might be due to genetically differences, difference in origin, growth habit and the environmental conditions of investigated cultivars. These differences observed in plants are either those treated with tap water (control) or those treated with garlic extract, ascorbic acid and nicotinamide.

Data presented in Tables 2 and 3 show the promotive effect of different treatments (garlic extract, ascorbic acid and nicotinamide) on growth parameters, yield and its components of faba bean cultivars. The results also indicate an increase in photosynthetic pigment contents. This growth improvement in faba cultivars can be established by the fact that garlic extracts contain various growth-promoting compounds such as starch and vitamins and organosulphur compounds such as allicin and diallyl disulphide (Puvača *et al*. 2014 and Martins *et al*. 2016). However, in the current findings, there seems to be a strong correlation between the morphological indices and the developmental aspects such as chlorophyll or IAA contents. Similar results were obtained by Mady (2009) on *Majorana hortensis* and *Salvia officinalis*. Likewise, Hanafy et al. (2012) reported that the highest values of plant height, stem diameter, dry weight of leaves/plant, leaf area, total carbohydrates and N contents in *Schefflera arboricola* were obtained with garlic extract. Moreover, Sikandar et al. (2018) reported that garlic extract treatment increased growth parameters of pepper plant. Osman et al. (2014) on sunflower plant, Gul et al. (2015) on Guar plant and Ahmed et al. (2016) confirmed the obtained results using ascorbic acid on chickpea plant and El-Bassiouny et al. (2017) on sunflower plant. Moreover, the positive role of ascorbic acid may be due to that ascorbic acid caused a stimulate influencing on many physiological processes, such as stimulate respiration activities, cell division and many enzymes activities, as reported by Zewail (2007), and its important role of regulation of photosynthetic carbon reduction (Helsper *et al.*, 1982). Moreover, Srivastava (1995) stated that foliar application increased photosynthetic rate, nutrient uptake from the soil to leaves and translocation of these nutrients from the leaves to seeds, thereby enhancing seed yield without spending any energy as well as without any loss in transit.

These results of nicotinamide are in agreement with those obtained by Sadak et al. (2010), Erdal et al. (2011), Sadak (2016) and Dawood et al. (2019). The stimulatory effects of nicotinamide on plant growth were found to be correlated with the increase in content and activity levels of endogenous promoters as IAA (Table 4) (Wilkins, 1989). Nicotinamide is known as a growth-regulating factor that influences many physiological processes such as biosynthesis of enzymes, nucleic acids and proteins and acts as a coenzyme (Hathout, 1995). These were further corroborated by the significantly higher levels of carbohydrates observed generally in the test plants nicotinamide treated (Sadak, 2016).

Photosynthetic pigment content and some physiological aspects of faba bean

All applied treatments caused marked increases in all components of photosynthetic pigments (*Chlo* a, *Chlo* b and total pigments), IAA, phenolics, carbohydrates constituents, free amino acids and proline contents compared with untreated control plants. The enhancement effect of different treatments (garlic

extract, ascorbic acid or nicotinamide) on photosynthetic pigments could be the result of its effect on chlorophyll biosynthesis and protection of chloroplast and increasing photosynthetic activities. The results of garlic extract effect on the photosynthetic pigments are congruent with those obtained by Mohamed and Akladious (2014) on soybean and El-Rokiek et al. (2019) on quinoa plant. Moreover, these increases in response to garlic extract could be established by the fact that garlic extracts contain various growth-promoting compounds such as starch and vitamins and organosulphur compounds such as allicin and diallyl disulphide (Puvaˇca *et al*. 2014 and Martins *et al*. 2016). However, in the current findings, there seems to be a strong correlation between the morphological indices and the developmental aspects such as chlorophyll contents. These results of ascorbic acid are in good agreement with those obtained on faba bean and sunflower plants (Sadak *et al.,* 2010 and El-Bassiouny *et al*., 2017). Moreover, data indicated that nicotinamide treatment was more effective than other treatments. The induced role of nicotinamide is confirmed by Sadak et al. (2010), Abdelhamid et al. (2013) and Dawood et al. (2019) on sunflower and faba bean. Nicotinamide could protect chloroplast and its membrane and maintain its integrity and protect chloroplast from oxidative damage (Taylor *et al.*, 1982 and Munne-Bosch *et al*., 2001). Different treatments caused significant increases in carbohydrate constituents, total phenolic content, proline and free amino acids relative to control (Table 5). These results could be showed by many authors El-Bassiouny et al. (2017) stated that the treatment of ascorbic acid to sunflower grass plants significantly increased the studied biochemical parameters. Dawood et al. (2019) confirmed the results of nicotinamide on faba bean plant. Robinson (1973) revealed that nicotinamide acts as a coenzyme in the enzymatic reactions of carbohydrates, fats and protein metabolism and involved in photosynthesis and respiration. These obtained results are in agreement with those of Dawood et al. (2019) in faba bean plant. Regarding phenolic contents, total phenolic contents play a significant mechanism in the regulation of plant metabolic processes and consequently of overall plant growth (Lewis and Yamamoto, 1990). Moreover, phenolic contents act as a substrate for many antioxidant enzymes, so, it mitigates stress injuries (Khattab, 2007).

Conclusion

It was concluded from the current field study that using different foliar applications is beneficial to mitigate sandy soil under a wide range of field conditions. The results of this study highlight the role of garlic extract in improving faba bean cultivars yield under sandy soil conditions which increased significantly grain yield/fed. To minimize the hazardous effects of abiotic stress on yield of faba bean cultivars, in general, garlic extract at the rate of 5% encourage the farmers to use it as a new natural and low-cost for stimulating to enhance faba bean that is mediated via improvement in yield and its components

Abbreviations

V1: Nubaria-1; V2: Nubaria-2; V3: Giza-843; P1: Garlic extract; P2: Ascorbic acid; P3: Nicotinamide; LA: Leaf area; IAA: Indole acetic acid; TSS: Total soluble sugars

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Authors' contributions

MHM designed and performed the experiment and wrote and reviewed the manuscript. EAB designed and performed the experiment, performed the statistical analysis and wrote and reviewed the manuscript. MShS designed and performed the experiment, is responsible of all the physiological and biochemical analysis and also wrote and reviewed the manuscript. HHK designed the experiment and farming plants and wrote and reviewed the manuscript. All authors read and approved the final manuscript.

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