Asian Journal of Plant Sciences

ISSN 1682-3974

science alert

ANSInet
an open access publisher
http://ansinet.com

OPEN ACCESS Asian Journal of Plant Sciences

ISSN 1682-3974
DOI: 10.3923/ajps.2022.39.48

Research Article
Impact of Calcium Sulphate Application and Humic Acid on Growth, Yield and Yield Components of Faba Bean (*Vicia faba* L.) under Sandy Soil Conditions

S.R.E. Abo-Hegazy and R.A. Badawy

Department of Agronomy, Faculty of Agriculture, Cairo University, Giza, Egypt

Abstract

Background and Objective: Faba bean (*Vicia faba* L.) is one of the most important food legumes in Egypt. The acreage's and seed yields vary from one season and location to another. This study aimed to investigate the effect of calcium sulphate application and humic acid on the growth, yield and yield components of faba bean under sandy soil conditions. **Materials and Methods:** Two field experiments were carried out to study the effect of calcium sulphate (gypsum) rates (0, 0.75 and1.5 t fed^{-1}), foliar spraying with three levels of humic acid (0, 1.5 and 3 g L^{-1}) and their interactions on yield and yield components of three cultivars of faba bean (Giza-843, Sakha-1 and Sakha-4). **Results:** The differences between the two calcium sulphate rates for agronomic traits and seed chemical composition were significant in the two seasons. Application of 1.5 ton $CaSo_4$ fed^{-1} gave the utmost values for most attributes studied traits in both seasons. Also, results showed that the differences between humic substance concentrations for all studied traits were significant in both seasons except HI. Foliar faba bean plants with 3 g L^{-1} humic acid fad^{-1} gave the highest values for all studied traits in the two seasons. Also, results showed that the differences between cultivars for all studied traits were significant in both seasons. G-843 faba bean cultivar gave the highest values for all studied traits within the two seasons. **Conclusion:** The most favourable effects for growth parameters and chemical composition traits resulted in the highest levels of $CaSo_4$ or humic acid for the Giza-843 cultivar.

Key words: Faba bean, cultivars, calcium sulphate, humic acids, foliar application, newly reclaimed lands, sandy soils

Citation: Abo-Hegazy, S.R.E. and R.A. Badawy, 2022. Impact of calcium sulphate application and humic acid on growth, yield and yield components of faba bean (*Vicia faba* L.) Under sandy soil conditions. Asian J. Plant Sci., 21: 39-48.

Corresponding Author: S.R.E. Abo-Hegazy, Department of Agronomy, Faculty of Agriculture, Cairo University, Giza, Egypt

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Faba bean (*Vicia faba* L.) is considered popular legume food consumed worldwide for use in both human consumption and animal nutrition in many parts of the world. Seeds have 26-35% protein, 55-61% total carbohydrate and 6.4-8.4% fibers[1,2]. It is one of the most important food legumes in Egypt. It is one of the promising crops which can play an important role in increasing legume production in Egypt[3]. Drought and salinity are the main factors that limit the productivity of faba beans as abiotic stresses. Exposure of plants to water-limiting or salt stresses during various developmental plant stages appears to activate various physiological and developmental changes[4,5]. Salinity stress has special importance in Egypt for both newly reclaimed lands and old cultivated areas[6].

As well, saline water was previously considered unusable for irrigation, however; this water needs now and in the future need to use successfully to grow crops under certain conditions[7,8]. Application of calcium sulphate and foliar spraying with humic acids may be an easy technique to overcome salinity problems, which because calcium sulphate has an important role in alleviates the adverse effects of salinity on many crop plants. Also, humic acid improves the plant tolerance to salinity stress or adverse conditions[9-11].

Several researchers studied the effect of calcium sulphate applications and foliar spraying with humic acids on field crops. The application of 800 kg in the form of $CaSo_4$ fed^{-1} significantly increased the yield and yield components of faba bean under sandy soil conditions[7]. Also, the application of 1200 kg ha^{-1} as $CaSo_4$ increased growth and yield traits[12].

Humic Acid (HA) is one of the used organic mineral fertilizers, HA has been shown to stimulate plant growth and increase yield by acting on mechanisms involved in water and nutrient uptake, cell respiration, photosynthesis, protein synthesis and enzyme activities[13]. Humic acid is one of the main components of humic substances. The humic matter is produced by the chemical and biological decomposition of organic material[14]. Under soil and water stress, foliar fertilization with humic acid had positive impacts on pods no. $plant^{-1}$, seed index and nitrogen content in seed and straw of faba bean plants[15].

This study aimed to investigate the effect of different calcium sulphate rates and humic acid concentrations on growth, yield and its components of three faba bean cultivars under newly reclaimed sandy soil conditions.

MATERIALS AND METHODS

Study area: Two field experiments were conducted under drip irrigation in the Desert Experimental Station, Fac. of Agriculture Cairo University in Wadi El-Natroon, El-Beheira Governorate, Egypt (located between 30°32'30'' and 30° 33'0'' N and between 29° 57'15'' and 29°58'15'' E with an altitude of 45 m) during 2017/18 and 2018/19 seasons. To study the effect of calcium sulphate application, foliar spraying with humic acids and their interaction on yield and its components of three faba bean (*Vicia faba* L.) cultivars. Soil and irrigation water properties are presented in Table 1. The soil of the experimental site was sandy, saline and poor in nutrients, as well as, organic matter. Irrigation water was saline. There were few differences in the soil properties between the two years of the study.

Table 1: Soil and irrigation water properties at the experimental site in 2017/2018 and 2018/2019 seasons

Soil analysis				2017/2018						2018/2019
Physical properties										
Sand (%)				94.85						92.50
Silt (%)				4.00						4.78
Clay (%)				1.15						2.72
Texture				Sandy						Sandy
Chemical properties										
Soil (pH)				7.89						7.53
Ec (ds m^{-1})				5.23						5.36
Organic matter (%)				0.30						0.25
Total $CaCO_3$ (%)				2.55						5.96
Available N (mg kg^{-1})				0.63						8.6
Available P (mg kg^{-1})				1.45						2.24
Available K (mg kg^{-1})				150						180
		EC		Ions concentration (meq L^{-1})						
Season	pH	ds m^{-1}	PPM	HCO_3^-	Cl^-	$So_4^=$	Ca^{++}	Mg^{++}	Na^+	K^+
Chemical properties of irrigation water										
2017-18	7.6	4.1	2624	2.9	30.1	9.0	3.9	4.3	33.3	0.64
2018-19	7.8	4.2	2688	3.5	28.8	7.7	5.5	4.5	31.6	0.54

Experimental design: The experimental design was a spilt-spilt plot design in randomized complete blocks (RCBD) arrangement, with three replications. Gypsum (Calcium sulphate) rates were devoted to main plots (0.0 and 1.5 t fed^{-1}), sub-plots were allocated to the humic acid concentrations (0.0, 1.5, 3.0 g L^{-1}) while, sub-sub plots to three Egyptian cultivars of faba bean (Sakha-1, Sakha-4 and Giza-843) that planted on 15th November in both seasons. Each sub-sub plot consisted of three rows of 3 m in length and 50 cm in width with an area of 4.5 m^2. Plant density was 26 plant m^{-2} were obtained by seeding two seeds/hill, spaced 30 cm apart on both sides of the ridge (50 cm width). All cultural practices were conducted according to the recommendations of ARC, Ministry of Agriculture concerning faba bean production.

Gypsum (calcium sulphate 97.28%): (22.6% Ca^{++}, 54.36% So_4^{-}, 18.12% S, Cl 0.67% and P 13.15 mL g^{-1}), were applied during soil preparation. The drip irrigation system is utilized in application irrigation water every five days from the sowing until maturity stage. Stopping irrigation was after 120 days from sowing in the two seasons. All other cultural practices were followed as recommended in faba bean production.

The samples were dried at 105°C in preparation for chemical analysis and ground through a 1 mm screen. The chemical compositions (Ash, Crude protein, Crude fibre and Carbohydrate) percentage of the faba bean seeds were determined.

Studied characters: At harvest, ten guarded plants were randomly taken from each sub-sub plot to estimate the following traits: branches pl^{-1}, pods pl^{-1}, seed yield pl^{-1} (g), seed index (100 seed weight (g)), biological yield ha^{-1} (t). In addition and seed yield ha^{-1} (t) was weighed from the whole area of each sub-sub plot and adjusted to yield per hectare. And the chemical composition of faba bean plants: Ash, crude protein, ether extract, crude fibre, carbohydrate, humic acids and mineral contents.

Data obtained from each season were statistically analyzed according to procedures outlined by Snedecor and Cochran[16] using the computer software, SPSS[17]. The differences between treatment means were compared by the least significant differences test (LSD) at a 0.05 level of significance.

RESULTS AND DISCUSSION

Significance of variances: The significance of variances due to the effects of two calcium sulphate rates and three humic acid concentrations on the performance of three faba bean cultivars for some traits are presented in Table 2. Both calcium sulphate rates (C) varied highly significantly (or significantly) for all studied traits under both seasons. Humic acid concentrations (H) affected highly significantly or significantly for all studied traits except HI (11.95 and 7.12 ns) under the two seasons, respectively. Cultivars (CVS) affected highly significant for all studied traits in both seasons.

Table 2: Significance of mean squares due to different sources of variation of evaluation the 3 faba bean cultivars under calcium sulphate rates and humic acid concentrations

Trait	Season	Calcium sulphate (C)	Humic (H)	C×H	Cultivars (CVS)	C×CVS	H×CVS	C×H×CVS
Pl height	017/018	374.99**	2508.49*	9.59*	1305.43*	30.68*	46.74*	10.69*
	018/019	1008.81**	932.14**	11.43*	354.23**	43.24**	13.86**	9.38*
Branches Pl^{-1}	017/018	5.17*	1.82*	0.35*	7.3*	0.27*	0.03^{ns}	0.09^{ns}
	018/019	3.28**	4.12**	0.27**	7.91**	0.02^{ns}	0.12^{ns}	0.05^{ns}
Pods Pl^{-1}	017/018	27.31*	29.07**	2.24*	1.08*	0.89*	0.70*	0.31*
	018/019	80.67**	26.75**	1.49*	94.14**	8.11**	0.55*	0.20*
Seeds Pl^{-1}	017/018	538.97**	653.88**	6.24*	311.31**	27.17**	3.34**	1.76*
	018/019	152.34**	1018.78**	10.68**	203.78**	25.83**	9.28**	4.92**
SY Pl^{-1}	017/018	559.06**	659.73**	9.43*	1131.36**	35.91**	20.42**	1.03*
	018/019	211.62**	901.76**	23.81**	939.82**	25.31**	33.36**	7.79**
SI	017/018	138.84*	184.58**	30.45*	4729.34**	5.21^{ns}	12.36*	8.72^{ns}
	018/019	130.51*	172.98**	27.56*	4421.98**	4.81^{ns}	11.37*	8.58^{ns}
HI	017/018	7.22*	11.95^{ns}	2.58^{ns}	211.97**	4.09^{ns}	7.35*	5.40*
	018/019	49.94**	7.12^{ns}	0.82^{ns}	585.82**	8.62^{ns}	1.17^{ns}	8.56**
Biological yield	017/018	6.33**	36.49**	0.30*	41.06**	0.23^{ns}	1.47**	0.09^{ns}
	018/019	4.51**	7.54**	0.80*	28.15**	0.14^{ns}	0.15^{ns}	0.16^{ns}
Yield ha^{-1}	017/018	0.83**	3.24**	0.27*	7.37**	0.07**	0.14**	0.03*
	018/019	1.31**	1.96**	0.21*	8.77**	0.03**	0.04**	0.04**

ns, * and ** indicate insignificant, significant at 0.05 and significant at 0.01, SY Pl^{-1}: Seed yield $plant^{-1}$, SI: Seed index, HI: Harvest index

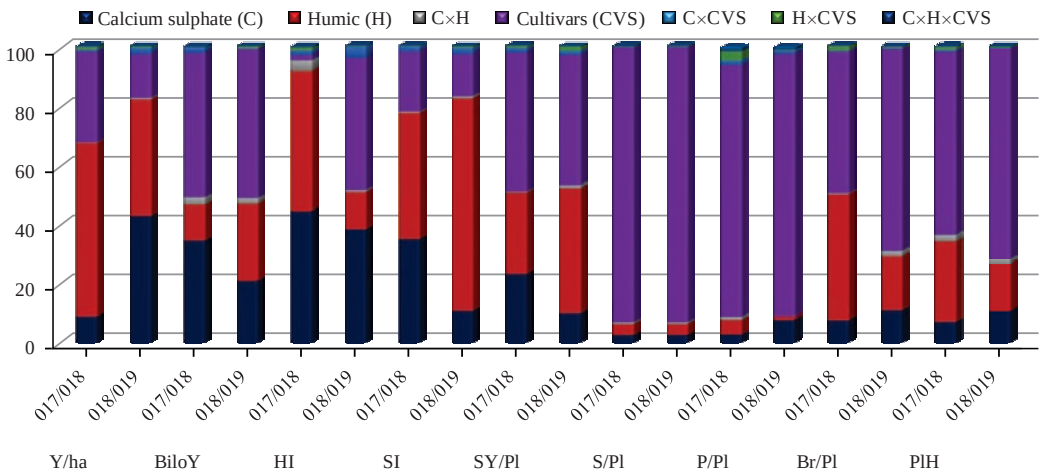

Fig. 1: Contribution of variance components to total variation for studied traits

PlH: Plant height, Br/Pl: Number of branches plant^{-1}, P/Pl: Number of pods plant^{-1}, S/Pl: Number of seeds plant^{-1}, SY/Pl: Seed yield plant^{-1}, SI: Seed index, HI: Harvest index, BiloY: Biological yield, Y/ha: Seed yield ha^{-1}

Calcium sulphate rates performed differently from humic acid concentrations to another for Pl. height, pods pl^{-1}, seeds pl^{-1}, Sy pl^{-1}, SI and yield ha^{-1} (9.59*, 2.24*, 6.24*, 9.43*, 30.45* and 0.27*) and (11.43*, 1.49*, 10.68**, 23.81**, 27.56* and 0.21*) in the two seasons, respectively. This is proved by the high significance of C×H interaction for all mentioned traits and non-significant interaction for HI (2.58 and 0.82 ns) in the two seasons, respectively. Similarly, significant variations due to C×CVS were recorded for all traits in both seasons, except SI, HI and biological yield (5.21, 4.09 and 0.23 ns) and (4.81, 8.62 and 0.14 ns) under both seasons, respectively. Thus, faba bean cultivars responded variably from the Calcium sulphate rate to another of the two investigated rates. However, humic acid concentrations×CVS interaction was significant and highly significant for all traits in both seasons except branches pl^{-1} (0.03 and 0.12 ns) in the two seasons, respectively and non-significant for HI and biological yield (1.17 and 0.15 ns) in 2018/2019 season. The second-order interaction, C x H x CVS, is significant for all traits under both seasons except, branches pl^{-1}, SI and biological yield. Therefore, it could be concluded that each faba bean cultivar is affected differently by various calcium sulphate rates and humic acid concentrations. In other words, the effects of calcium sulphate rates and humic acid concentrations on different faba bean cultivars varied according to different rates and concentrations.

For all studied traits, the contribution of cultivars to observed variation was the largest except for HI (1.75%) in the 1st season in Fig. 1. For yield ha^{-1}, the effects of cultivars, Humic and Calcium sulphate were accounted for 70.95, 61.67, 15.86, 27.11, 10.60 and 6.95% of the total variability in the 2nd and 1st seasons, respectively. The contributions of two-way and three-way interactions (C×H, C×CVS, H×CVS and C×H ×CVS) effect to total variation were low (Fig. 1).

Growth, yield and yield components: Results indicated that the differences between calcium sulphate rates significantly differed for all studied traits in 2017/2018 and 2018/2019 seasons. Application of 1.5 t $CaSo_4$ fed^{-1} showed the maximum and significant values for all studied traits in both seasons (60.01, 2.73, 11.31, 33.60, 28.58, 80.85, 28.74, 6.89 and 2.01) and (54.11, 2.81, 11.95, 32.66, 26.84, 78.01, 34.96, 5.74 and 2.05), respectively in Table 3 and 4. Positive effects of $CaSo^4$ application with 1.5 ton fed^{-1} on yield and its components may be due to $CaSo_4$ important role in alleviates the adverse effects of salinity on faba bean plants from through substitution Na^+ with Ca^{++} cation, consequently, dimensions Na^+ and Cl^- out the cell or relegation on root system range, also, the important role of SO_4 in formation H_2SO_4, which, led to increasing soil acidity, removal of the calcareous problem, which, in relation with salinity, with addition to, sulphur role in mineralization process from through chemotrophic sulphur bacteria and an important as an element to form some of the humic acids such as cysteine, biotin and thiamine, sulphur is essential element information of glycosides such as chloroplasts, which, contain on chlorophyll. Consequently, the components of $CaSo_4$ led to alleviates high salt concentrations in the soil solution and low soil water potential (drought stress), also, removal toxic ions such as Na^+ and Cl^- and nutrient balance, consequently increased elements uptake and shoot transport of minerals, that, led to enhanced yield character and its yield component

of faba bean under irrigation conditions with saline water. These results are completely in agreement with some investigations[7,18-21].

Regarding humic acid foliar application, resulted in Table 3 and 4 showed the significant effects of humic acid concentrations for all studied traits in both seasons except HI (28.45, 27.52 and 29.14) for (0.0, 1.5 and 3.0) humic acid concentrations, respectively. Foliar faba bean plants with concentrates 1.5 or 3.0 g L^{-1} humic acid, two times after 45 and 60 days from sowing date gave the maximum values for all studied traits, while the minimum values were obtained from the control in the two seasons (45.33, 2.08, 9.18, 24.91, 19.80, 76.12, 28.45, 4.95 and 1.43) and (42.51, 2.10, 9.39, 23.71, 18.13, 73.43, 33.37, 4.84 and 1.65) for all studied traits, respectively. Positive effects of the high concentration of humic acid on these traits may be due to its action on different physiological and metabolic processes. Humic acid increased photosynthetic rate and 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[22], respiration, biosynthesis of nucleic acid, enzyme and overall, plant dry weight[23,24]. Moreover, the application of humic acid to foliage and soil increased auxin, cytokinin and Gibberellin levels in plants and improved plant growth. As well, humic acid is a hormone-like substance; its auxin-like activity stimulated cell division and cell elongation[25]. Furthermore, the humic acid was able to produce positive effects in improving the fresh and dry biomass of faba bean plants[14,26]. Humic acid treatment enhanced the overall metabolism of crop plants and overall photosynthetic rate and hence the yield in general[27]. Many researchers concluded the enhancing effect of humic acid on growth, yield and nutrient uptake by many crops[28,29]. The interaction between calcium sulphate rates and foliar spraying with humic acid concentrations was significant for all studied traits in both seasons except HI.

Results in Table 3 and 4 indicated that the differences between cultivars were significant for all studied traits in two seasons. G-843 cultivar showed the maximum values for all studied traits in both seasons and Sakha-1 showed the minimum values for all studied traits in both seasons except no. of seeds pl^{-1} in the 1st season Sakha-4 showed the minimum value (27.92). Positive effects of the G-843 cultivar on yield and its components may be due to the adaptability of the cultivar under salinity conditions.

Regarding the interaction of calcium sulphate and humic acid factors data in Table 3 and 4 indicated that vegetative, yield and yield components characters of faba bean plants were significant in both seasons. The obtained data showed that the highest values of studied characters were recorded when used 1.5 t fed^{-1} of calcium sulphate with the highest level of humic acid (3 g L^{-1}) as compared to the other interaction treatments. These results were in harmony with those reported by many researchers[25,7]. And it is evident from Table 3 and 4, that variety G-843 recorded the greatest values for all traits with 0 and 1.5 t ha^{-1} in both seasons.

It is evident from the records in Table 3 and 4 that the interaction of calcium sulphate and cultivars was significant for all studied traits in both seasons and G-843 showed the highest values for all traits with 0.0 and 1.5 t ha^{-1} in both seasons. Also, data listed in the same tables showed significant differences were recorded for the interaction of humic and cultivars and G. 843 was superior with all concentrations of humic. On the other hand, the lowest values were recorded for Sakha-1 for all studied traits in both seasons. These results are in agreement with many researchers, that they indicated that foliar field crops with humic acids increased growth, yield and yield components, especially, under salinity conditions[7,30,31].

Chemical composition: The significance of variances due to the effects of calcium sulphate and humic acid on the performance of three faba bean cultivars for some chemical compositions are presented in Table 5. Both calcium sulphate rates (C) varied highly significantly (or significantly) for all studied traits. Humic acid concentrations (H) and cultivars (CVS) were affected highly significantly for all studied traits. Calcium sulphate rates performed differently from humic acid concentrations to another for all studied traits. This is proved by the significance and highly significant of C×H interaction for all mentioned traits. Similarly, significant variations due to C×CVS were recorded for crude protein and carbohydrate and non-significance foe ash and fibre. However, humic acid concentrations x CVS interaction was significant and highly significant for all studied traits. The second-order interaction, C x H x CVS, is insignificant for all traits. Therefore, it could be concluded that each faba bean cultivar is not affected differently by various calcium sulphate rates and humic acid concentrations. In other words, the effects of calcium sulphate rates and humic acid concentrations on different faba bean cultivars not varied according to different rates and concentrations.

The chemical properties of three faba bean genotypes that are affected by calcium sulphate rates (C) and foliar spraying with humic acid concentrations (H) under irrigation conditions with saline water in the 2018/2019 season are presented in Table 6.

Table 3: Yield and yield components as affected by calcium sulphate application and foliar spraying with humic acid concentrations under irrigation conditions with saline water in the 2017/2018 season

Calcium sulphate rates (t fed^{-1})	Humic acid conc. (g L^{-1})	Varieties	Plant height (cm)	Number of branches Pl^{-1}	Pods Pl^{-1}	Number of seeds pl^{-1}	Seed yield Pl^{-1} (g)	Seed index (SI) (g)	Harvest index (HI)	Biological yield (t ha^{-1})	Seed yield (t ha^{-1})
Mean effects of calcium sulphate rates											
0			54.74	2.11	9.89	27.29	22.15	77.64	28.01	6.22	1.77
1.5			60.01	2.73	11.31	33.60	28.58	80.85	28.74	6.89	2.01
Significance			**	*	*	**	**	*	*	**	**
Mean effects of humic acid concentrations											
	0.0		45.33	2.08	9.18	24.91	19.80	76.12	28.45	4.95	1.43
	1.5		57.88	2.45	11.02	29.56	24.49	79.08	27.52	7.03	1.96
	3.0		68.93	2.72	11.62	36.87	31.81	82.52	29.14	7.68	2.27
$LSD_{0.05}$			1.584	0.114	0.323	0.791	0.839	1.598	ns	0.253	0.069
		Sakha-1	48.98	1.73	7.91	28.17	17.86	61.02	25.08	4.88	1.22
		Sakha-4	57.16	2.53	10.74	27.92	24.58	84.63	28.10	6.97	1.96
		Giza-843	66.01	2.99	13.16	35.24	33.66	92.07	31.93	7.81	2.50
$LSD_{0.05}$			2.00	0.129	0.384	0.513	0.557	1.243	1.074	0.204	0.0576
Calcium sulphate × humic acid											
0.0	0.0		43.49	1.74	8.12	22.01	17.39	75.91	28.52	4.48	1.30
	1.5		55.10	2.11	10.67	25.72	20.71	77.26	26.97	6.81	1.87
	3.0		65.64	2.47	10.89	34.12	28.34	79.74	28.52	7.37	2.13
1.5	0.0		47.18	2.42	10.23	27.81	22.20	76.33	28.38	5.42	1.57
	1.5		60.66	2.79	11.37	33.39	28.28	80.90	28.07	7.25	2.06
	3.0		43.49	1.74	8.12	22.01	17.39	75.91	28.52	4.48	1.30
$LSD_{0.05}$			2.436	0.261	0.4573	1.119	1.186	1.186	ns	0.93	0.84
Calcium sulphate × varieties											
	0.0	Sakha-1	47.30	1.56	7.20	25.72	15.77	59.27	25.09	4.67	1.16
		Sakha-4	53.03	2.19	9.79	25.47	21.82	82.58	27.20	6.53	1.77
		Giza-843	63.90	2.58	12.69	30.67	28.86	91.06	31.73	7.45	2.37
	1.5	Sakha-1	50.66	1.90	8.62	30.61	19.95	62.78	25.07	5.09	1.28
		Sakha-4	61.28	2.88	11.70	30.38	27.35	86.68	29.00	7.40	2.14
		Giza-843	68.11	3.40	13.62	39.82	38.46	93.08	32.13	8.17	2.62
$LSD_{0.05}$			2.829	0.182	0.543	0.726	0.787	ns	ns	ns	0.0814
Humic acid × varieties											
	0.0	Sakha-1	40.25	1.45	6.70	23.20	14.25	59.35	24.71	3.79	0.93
		Sakha-4	44.68	2.17	9.57	22.75	18.76	79.85	28.94	4.79	1.39
		Giza-843	51.07	2.63	11.27	28.78	26.38	89.17	31.71	6.27	1.99
	1.5	Sakha-1	48.08	1.78	8.40	27.08	16.83	60.12	24.63	5.27	1.29
		Sakha-4	57.10	2.58	10.90	27.05	24.02	85.79	25.85	7.68	1.98
		Giza-843	68.45	2.98	13.75	34.53	32.63	91.34	32.08	8.14	2.62
	3.0	Sakha-1	58.60	1.95	8.63	34.22	22.51	63.61	25.91	5.58	1.45
		Sakha-4	69.68	2.85	11.77	33.97	30.96	88.25	29.52	8.43	2.49
		Giza-843	78.50	3.35	14.45	42.42	41.96	95.71	32.00	9.02	2.89
$LSD_{0.05}$			3.465	ns	0.665	0.889	0.964	2.153	1.861	1.118	0.100
C × H × V			*	ns	*	*	*	ns	*	ns	*

Table 4: Yield and its components as affected by calcium sulphate application and foliar spraying with humic acid concentrations under irrigation conditions with saline water in the 2018/2019 season

Calcium sulphate rates (t fed^{-1})	Humic acid conc. (g L^{-1})	Varieties	Plant height (cm)	Number of branches Pl^{-1}	Pods Pl^{-1}	Number of seeds pl^{-1}	Seed yield Pl^{-1} (g)	Seed index (SI) (g)	Harvest index (HI)	Biological yield (t ha^{-1})	Seed yield (t ha^{-1})
Mean effects of calcium sulphate rates											
0			45.47	2.32	9.51	29.30	22.88	74.90	33.04	5.16	1.74
1.5			54.11	2.81	11.95	32.66	26.84	78.01	34.96	5.74	2.05
Significance			**	**	**	**	**	*	**	**	**
Mean effects of humic acid concentrations											
	0.0		42.51	2.10	9.39	23.71	18.13	73.43	33.37	4.84	1.65
	1.5		49.98	2.54	11.01	30.48	24.21	76.31	34.00	5.39	1.88
	3.0		56.89	3.06	11.78	38.73	32.24	79.62	34.63	6.13	2.16
$LSD_{0.05}$			1.379	0.081	0.389	0.820	0.763	1.558	ns	0.217	0.769
		Sakha-1	45.35	1.86	8.22	29.05	17.73	58.83	27.47	4.32	1.19
		Sakha-4	49.81	2.66	11.28	29.02	24.67	81.68	36.56	5.23	1.91
		Giza-843	54.22	3.18	12.69	34.86	32.18	88.85	37.98	6.80	2.58
$LSD_{0.05}$			1.199	0.187	0.392	0.706	0.710	1.214	1.734	0.210	0.044
Calcium sulphate × humic acid											
0.0	0.0		38.78	1.77	7.87	22.14	16.88	73.20	32.61	4.50	1.49
	1.5		45.97	2.43	10.06	29.51	22.83	74.55	33.06	5.07	1.72
	3.0		51.67	2.76	10.60	36.23	28.94	76.94	33.45	5.91	2.01
1.5	0.0		46.23	2.43	10.92	25.28	19.39	73.65	34.13	5.17	1.81
	1.5		53.99	2.64	11.97	31.46	25.59	78.06	34.94	5.71	2.04
	3.0		62.12	3.36	12.97	41.23	35.55	82.30	35.81	6.34	2.31
$LSD_{0.05}$			1.037	0.114	0.550	1.160	1.079	2.204	ns	1.019	0.057
Calcium sulphate × varieties											
0.0		Sakha-1	42.44	1.61	7.72	28.12	16.62	57.16	27.02	3.96	1.07
		Sakha-4	45.72	2.44	9.47	27.97	23.17	79.67	35.87	4.92	1.76
		Giza-843	48.24	2.90	11.33	31.80	28.85	87.86	36.23	6.60	2.39
1.5		Sakha-1	48.26	2.11	8.71	29.98	18.84	60.51	27.91	4.69	1.31
		Sakha-4	53.89	2.87	13.10	30.07	26.17	83.68	37.25	5.54	2.07
		Giza-843	60.20	3.46	14.04	37.92	35.51	89.83	39.73	6.99	2.78
$LSD_{0.05}$			1.696	ns	0.555	0.999	1.004	ns	ns	ns	0.062
Humic acid × varieties											
	0.0	Sakha-1	39.30	1.45	6.62	22.32	13.18	57.19	26.87	3.87	1.03
		Sakha-4	42.15	2.07	10.28	22.50	17.91	77.07	36.27	4.48	1.62
		Giza-843	46.07	2.78	11.28	26.32	23.31	86.02	36.99	6.16	2.28
	1.5	Sakha-1	46.28	1.85	8.80	28.93	17.29	57.96	27.08	4.22	1.14
		Sakha-4	49.53	2.77	11.33	28.38	24.28	82.82	36.58	5.15	1.89
		Giza-843	54.12	3.00	12.90	34.13	31.05	88.15	38.34	6.81	2.61
	3.0	Sakha-1	50.47	2.28	9.23	35.90	22.73	61.35	28.45	4.88	1.39
		Sakha-4	57.73	3.13	12.23	36.17	31.81	85.14	36.83	6.07	2.23
		Giza-843	62.48	3.75	13.88	44.13	42.18	92.38	38.61	7.42	2.86
$LSD_{0.05}$			2.077	ns	0.598	1.223	1.230	2.103	ns	ns	0.075
C × H × V			*	ns	*	**	**	ns	**	ns	**

ns, * and ** indicate insignificant, significant at 0.05 and significant at 0.01, respectively

Table 5: Significance of mean squares due to different sources of variation of evaluation faba bean seeds chemical composition (%) under calcium sulphate rates and humic acid concentrations in 2018/2019 season

Trait	Calcium sulphate (C)	Humic (H)	C×H	Cultivars (CVS)	C×CVS	H×CVS	C×H×CVS
Ash	2.386**	6.939**	0.441**	0.202**	0.001^{ns}	0.052**	0.008^{ns}
Crude protein	27.421*	120.144**	3.232*	4.043**	0.769*	1.211**	0.103^{ns}
Crude fiber	9.383**	9.635**	1.415**	0.189**	0.014^{ns}	0.047*	0.026^{ns}
Carbohydrate	235.418**	164.954**	19.155**	5.978**	1.080*	2.351*	1.326^{ns}

ns, * and ** indicate insignificant, significant at 0.05 and significant at 0.01, respectively

Table 6: Effect of calcium sulphate application and foliar spraying with humic acid concentrations on chemical compositions (%) in faba bean seeds under irrigation conditions with saline water during 2018/2019 season

	Humic acid conc. (g L^{-1})	Varieties	Ash	Crude protein	Crude fiber	Carbohydrate
Calcium sulphate rates (t fed^{-1})						
0			3.45	26.37	5.06	60.11
1.5			3.87	27.80	5.89	64.29
Significance			**	*	**	**
	0.0		3.12	24.85	4.72	59.17
	1.5		3.52	26.50	5.51	62.19
	3.0		4.34	29.91	6.18	65.23
$LSD_{0.05}$			0.2560	0.852	0.253	1.182
		Sakha-1	3.56	26.61	5.38	61.66
		Sakha-4	3.65	27.09	5.46	62.13
		Giza-843	3.77	27.56	5.58	62.81
$LSD_{0.05}$			0.146	0.269	0.141	0.898
Calcium sulphate×humic acid						
0.0	0.0		2.84	24.35	4.42	55.90
	1.5		3.20	26.06	5.30	60.75
	3.0		4.31	28.71	5.45	63.68
1.5	0.0		3.40	25.35	5.02	62.45
	1.5		3.84	26.94	5.73	63.62
	3.0		4.37	31.11	6.92	66.78
$LSD_{0.05}$			0.260	0.852	0.253	0.980
Calcium sulphate×varieties						
0.0		Sakha-1	3.34	25.95	4.96	59.65
		Sakha-4	3.44	26.39	5.01	60.01
		Giza-843	3.57	26.78	5.20	60.67
1.5		Sakha-1	3.77	27.27	5.80	63.67
		Sakha-4	3.87	27.79	5.90	64.24
		Giza-843	3.97	28.34	5.97	64.94
$LSD_{0.05}$	ns	0.923	ns	0.837		
Humic acid×varieties						
	0.0	Sakha-1	2.91	24.74	4.54	58.85
		Sakha-4	3.19	24.90	4.81	58.76
		Giza-843	3.26	24.90	4.82	59.91
	1.5	Sakha-1	3.52	26.15	5.47	61.87
		Sakha-4	3.46	26.42	5.43	62.63
		Giza-843	3.58	26.93	5.64	62.08
	3.0	Sakha-1	4.24	28.93	6.14	64.27
		Sakha-4	4.31	29.96	6.13	64.99
		Giza-843	4.47	30.85	6.29	66.43
$LSD_{0.05}$			0.226	0.466	0.244	1.56
C×H×V			ns	ns	ns	ns

ns, * and ** indicate insignificant, significant at 0.05 and significant at 0.01, respectively

Results revealed that cultivars differed significantly in ash and value ranged from3.56-3.77%. The results demonstrate the considerable genetic variation for ash, protein, fibre and carbohydrate. The range in protein content extended from 26.61-27.56%, for Sakha-1 and Giza-843, respectively. The fibre contents ranged from 5.38-5.58%with significant differences among genotypes. This is in agreement with values obtained by many researchers[32,7]. Carbohydrate ranged from 61.66-62.81% which is in harmony with the mean carbohydrate content for raw legumes[30]. Statistical analysis revealed

significant differences within the genotypes. Variations in these traits among different genotypes can be attributed to genetic and environmental factors[33].

Calcium sulphate rates (C) performed significantly different from humic acid concentrations (H) to another for all studied traits. G-843 showed highly significant performance under 1.5 t calcium sulphate rate and Sakha-1 showed the lowest significant values for crude protein and carbohydrate content. Thus, significant differences due to H×CVS were recorded for all studied chemical composition traits.

This study which was carried out during two sowing seasons in Wadi El-Natroon, El-Beheira Governorate, Egypt to assess the effect of calcium sulphate and humic acid concentrations on three faba bean cultivars has shown that G. 843 can serve as a good resource for protein, fibre and carbohydrate and support any program to alleviate protein malnutrition and recommended for commercial and extensive faba bean farming in the new reclaimed sandy soils as a result of its capacity to give high yield and protein content under saline soil conditions.

CONCLUSION

G-843 Cultivar gave high yield and yield components of faba bean due to its adaptation to Wadi El-Natron environment. Consequently, the supply of calcium sulphate and humic acid increased the growth, yield, yield components and seed chemical compositions and markedly alleviated the negative effects of abiotic stresses on faba bean plants and is considered as a promising soil amendment to overcome adverse effects of salinity stress.

SIGNIFICANCE STATEMENT

This study has discovered findings that there are differences in the interaction of faba bean (*Vicia faba* L.) varieties and application of calcium sulphate and humic acid under sandy slain conditions on growth, yield, yield components and seeds chemical composition. This investigation will assist researchers and farmers to use varieties and application calcium sulphate and humic acid on faba bean varieties under sandy and slain soil conditions. Based on this study a new theory has been obtained that, the use of the application of 1.5 t calcium sulphate, 3 g L^{-1}. humic acid on the G-843 variety can increase the yield, yield components and seeds chemical compositions.

REFERENCES

1. Hossain, M.S. and M.G. Mortuza, 2006. Chemical composition of kalimatar, a locally grown strain of faba bean (*Vicia faba* L.). Pak. J. Biol. Sci., 9: 1817-1822.
2. Alghamdi, S.S., 2009. Chemical composition of faba bean (*Vicia faba* L.) genotypes under various water regimes. Pak. J. Nutr., 8: 477-482.
3. Megawer, E.A., A.M.A. El-Sherif and M.S. Mohamed, 2017. Performance of five faba bean varieties under different irrigation intervals and sowing dates in newly reclaimed soil. Int. J. Agron. Agri. Res., 10: 57-66.
4. Ashraf, M. and M.R. Foolad, 2007. Roles of glycine betaine and proline in improving plant abiotic stress resistance. Environ. Exp. Bot., 59: 206-216.
5. Sadak, M.S.H., M.T. Abdelhamid and U. Schmidhalter, 2015. Effect of foliar application of aminoacids on plant yield and some physiological parameters in bean plants irrigated with seawater. Acta Biologica Colombiana, 20: 141-152.
6. Hellal, F.A., M.T. Abd El-Hamid, M.D. Abo- Basha and R.M. Zewainy, 2012. Alleviation of the adverse effects of soil salinity stress by foliar application of silicon on faba bean (*Vica faba* L.). J. Appl. Sci. Res., 8: 4428-4433.
7. Mesbah, E.A.E., 2016. Effect of calcium sulphate application and foliar spraying with amino acids on yield and yield components of faba bean (*Vicia faba* L.) in sandy soils. Middle East J. Agric. Res., 5: 307-312.
8. Zeid, I.M., 2011. Alleviation of seawater stress during germination and early growth of barley. Int. J. Agric. Res. Rev., 11: 59-67.
9. Mohamed, W.H., 2012. Effects of humic acid and calcium forms on dry weight and nutrient uptake of maize plant under saline condition. Aust. J. Basic Appl. Sci., 6: 597-604.
10. El-Galad, M.A., D.A. Sayed and R.M. El-Shal, 2013. Effect of humic acid and compost applied alone or in combination with sulphur on soil fertility and faba bean productivtiy under saline soil conditions. J. Soil Sci. Agric. Eng., 4: 1139-1157.
11. Shafeek, M.R., Y.I. Helmy, M.O. Nadia and F.A. Rizk, 2013. Effect of foliar fertilizer with nutritional compound and humic acid on growth and yield of broad bean plants under sandy soil conditions. J. Appl. Sci. Res., 9: 3674-3680.
12. Mona, A.M., M.A. Sabah and A.M. Rehab, 2011. Influence of potassium sulfate on faba bean yield and quality. Aust. J. Basic Appl. Sci., 5: 87-95.
13. Dawood, M.G., Y.R. Abdel-Baky, M.E.S. El-Awadi and G.S. Bakhoum, 2019. Enhancement quality and quantity of faba bean plants grown under sandy soil conditions by nicotinamide and/or humic acid application. Bull. Nat. Res. Cent., Vol. 43. 10.1186/s42269-019-0067-0.

14. Khafaga, E.E.E., S.A. Hasanin and R.M. El-Shal, 2014. Effect of foliar application with ascorbic, humic acids and compost tea on nutrients content and faba bean productivity under sandy soil conditions. J. Soil Sci. Agric. Eng., 5: 767-778.
15. El-Ghamry, A.M., K.M.A. El-Hai and K.M. Ghoneem, 2009. Amino and humic acids promote growth, yield and disease resistance of faba bean cultivated in clayey soil. Austr. J. Basic Appl. Sci., 3: 731-739.
16. Snedecor, G.W. and W.G. Cochran, 2014. Statistical Methods. 8th Edn., Iowa State University Press, Ames, IA, USA, ISBN-13: 978-0813815619, Pages: 503.
17. SPSS, 2019. SPSS for Windows, version 26.0. SPSS Inc., Chicago, USA.
18. Hu, Y. and U. Schmidhalter, 2005. Drought and salinity: A comparison of their effects on mineral nutrition of plants. J. Plant Nutr. Soil Sci., 168: 541-549.
19. Khalil, N.A. W.A. Al-Murshidy, A.M. Eman and R.A. Badawy, 2015. Effect of plant density and calcium nutrition on growth and yield of some faba bean varieties under saline conditions. J. Inter. Sci. Public., 3: 440-450.
20. Mehaseb, M.I., F.A. Al- Kamar and K.A.H. Shaban, 2018. Impact of sulphur sources on some soil properties, status of nutrients in grains maize and productivity under saline soil conditions. Ann. Agric. Sci., Moshtohor, 56: 1111-1120.
21. Rashed, S.H. and M.A. Ibrahim, 2020. Effectiveness of gypsum particle size and vermicompost in reclaiming salt affected soils and faba beans productivity. J. Soil Sci. Agric. Eng., 11: 437-444.
22. Atiyeh, R.M., S. Lee, C.A. Edwards, N.Q. Arancon and J.D. Metzger, 2002. The influence of humic acids derived from earthworm-processed organic wastes on plant growth. Bioresour. Technol., 84: 7-14.
23. Ulukan, H., 2008. Effect of soil applied humic acid at different sowing times on some yield components in wheat (*Triticum* spp.) hybrids. Int. J. Bot., 4: 164-175.
24. Said-Al Ahl, H.A.H., A.G. El Gendy and E.A. Omer, 2016. Humic acid and indole acetic acid affect yield and essential oil of dill grown under two different locations in Egypt. J. Pharm. Sci. Res., 8: 146-157.
25. Bayoumi, M.A. and T.A. Selim, 2012. Effect of nitrogen, humic acid and bio-fertilization on productivity and quality of faba bean under saline condition. J. Soil Sci. Agric. Eng., Mansoura Univ., 3: 829-843.
26. Meganid, A.S., H.S. Al-Zahrani and M.S. El-Metwally, 2015. Effect of humic acid application on growth and chlorophyll contents of common bean plants (*Phaseolus vulgaris* L.) under salinity stress conditions. Int. J. Innovative Res. Sci. Eng. Technol., 4: 2651-2660.
27. Zeng, K., H.M. Hwang and H. Yuzuri, 2002. Effect of dissolved humic substances on the photochemical degradation rate of 1-aminopyrene and Atrazine. Int. J. Mol. Sci., 3: 1048-1057.
28. El-Hefny, E.M., 2010. Effect of saline irrigation water and humic acid application on growth and productivity of two cultivars of cowpea (*Vigna unguiculata* L. Walp). Aust. J. Basic Applied Sci., 4: 6154-6168.
29. Saruhan, V., A. KuÅŸvuran and S. Babat, 2011. The effect of different humic acid fertilization on yield and yield components performances of common millet (*Panicum miliaceum* L.). Sci. Res. Essays, 6: 663-669.
30. Zeidan, M.S., M.O. Kabesh and M.S.M. Saber, 2002. Utilization of biofertilizers in field crop production 14 effect of organic manuring and biofertilization yield and composition of two faba bean varieties cultivated in a newly reclaimed soil. Egypt, J. Agron., 23: 47-57.
31. Turan, M.A., B.B. Aşik, A.V. Katkat and H. Çelik, 2011. The effects of soil-applied humic substances to the dry weight and mineral nutrient uptake of maize plants under soil-salinity conditions. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 39: 171-177.
32. Hendawey, M.H. and A.M.A. Younes, 2013. Biochemical evaluation of some faba bean cultivars under rainfed conditions at El-Sheikh Zuwayid. Ann. Agric. Sci., 58: 183-193.
33. Musallam, I.W., G.N. Al-Karaki and K.I. Ereifej, 2004. Chemical composition of faba bean genotypes under rainfed and irrigation conditions. Int. J. Agric. Biol., 6: 359-362.