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Influence of humic acid rates and phosphorus fertilization levels on the yield of two faba bean (*Vicia faba* L.) varieties

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Abstract

A field experiment was carried out at the Experimental Farm Faculty of Agriculture, Al-Azhar University at Assiut branch, Egypt during two successive growing seasons, 2021/2022 and 2022/2023, to study the influence of humic acid rates and phosphorus fertilization levels on the yield of two faba bean (*Vicia faba L.*) varieties *i.e.* Two faba bean varieties (Misr-1 and Giza-843) and three phosphate fertilization levels (15, 22.5 and 30 kg P_2O_5/fad.) and three humic acid rates (without addition, 6 and 12 kg/fad.). The results showed that the increase in faba bean plants resulting from adding rates of humic acid and phosphate fertilization which led to a significant increase in the number of branches/plant, number of pods/plant, seed weight/plant, 100-seed weight, seed yield/fad. and protein content. The faba bean variety Misr-1 gave the highest values of all traits compared to the Giza-843 faba bean variety used in both seasons. There were significant differences between faba bean varieties for all the traits studied. Phosphate fertilization is significantly affected by all the previous characters. The highest values for all studies characters resulted from using 30 kgP_2O_5/fad. Comparison of other phosphate fertilization treatments in both seasons. Humic acid levels showed significant differences in all studied characters. The highest treatment was obtained when adding 12 kg of humic acid/fad. and 30 kg of P_2O_5/fad. for the Misr-1 variety.

Keywords: Phosphorus fertilizer, humic acid, varieties, yield, faba bean, influence.

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1. Introduction

The Plant faba bean (*Vicia faba L.*) a winter annual, is considered an important yield for a plant of the legume family (Fabaceae). Faba beans are considered the first leguminous crop in the Arab Republic of Egypt in terms of cultivated area, total production and consumption. Its green and dry seeds are consumed in human nutrition because they contain a high percentage of protein, reaching about 28% and carbohydrates 58%. In addition to many vitamins and other nutrients, legumes are grown worldwide due to their important benefits, since they produce nutritional and healthy products, together with their positive effect of maintaining the sustainability of agricultural systems through N2 fixation and diversification of cropping. This is in addition to the role of the faba beans in improving the properties of the soil and increasing its fertility. About 20-30 nitrogen units per acre are left behind after harvest, and the next crop benefits from it. The faba bean seeds, as well as the hay, can be used as good fodder for animals. Egypt ranked fifth in the order of the ten biggest producers in the world after China, Ethiopia, Australia, and France. Production in Egypt reached 4188.4 kg/ha. [1]. It is important to optimize the productivity of stable varieties under favorable environmental conditions, agricultural practices and phosphorus fertilizer to increase faba bean production, especially under climate change [2,3]. Recent studies are geared towards increasing production efficiency through experimenting with the cultivation of good genotypes with high productivity and good quality appropriate to the conditions of agricultural areas and highlight the importance of using humic acid and phosphate and reducing the use of mineral fertilizers to reduce environmental pollution and reduce costs for farmers. Phosphorus is one of the major plant nutrients limiting growth due to its role in improving the nodulation process and BNF, root and nodule development, plant growth and formation of phosphoglycolate needed in photosynthesis. Therefore, even if soils contain high amounts of phosphorus, it is largely unavailable to the plant owing to its high reactivity with soil components such as iron, aluminum and calcium, which result in the formation of

highly insoluble forms of phosphorus [4]. However, approximately 70% of cultivated soils suffer from P limitation [5]. Only 20% to 30% of applied phosphate is used and absorbed by the plants and the remaining is lost due to interaction with soil components and microorganisms or run-off from soils to lakes, rivers and seas [6]. Humic acid is one of the most economical commercial products and is fast and harmless to humans, animals and plants. In addition, humic acid improves soil fertility and increases nutrient readiness [7]. Also, it showed that the application of humic acid resulted in a significant increase in the number of branches/plant, number of pods/plant, seed weight/plant, 100-weight seed, seed yield and protein content by increasing humic acid [8].

The objective of the present study was the influence of humic acid and phosphorus fertilization on two faba bean varieties, evaluating their quality, morphological, physiological, and agronomical traits.

2. Materials and Methods

A field experiment was carried out at the Experimental Farm Faculty of Agriculture, Al-Azhar University at Assiut, Egypt, during two successive growing seasons, 2021/2022 and 2022/2023, to study the influence of two varieties of faba bean (Misr-1 and Giza-843) on three different phosphate fertilization levels (15, 22.5 and 30 kg P_2O_5/fad.) and different humic acid rates (without addition, 6 and 12 kg/fad.). The experiment was designed as a split-split plot with three replications. Faba bean varieties were assigned to the main plot. Phosphate fertilizer levels were distributed randomly in the sub-plots and humic acid rates were located in the sub- sub-plots. The experimental unit area was 3.5 m long x 3.0 m wide (10.5 m^2 in area =1/400 /fad.) and comprised five ridges in this study. The plants were sown on the two sides of ridges, on hills 25cm apart and thinned to two plants /hill. Sowing dates were on 18th and 25th October in the first and second seasons, respectively. The preceding summer's crop was maize and the second season was sorghum in both seasons and the harvest was on 5th and 10th April in the first and second seasons, respectively. All other practices were uniformly applied as recommended for faba bean production in the region.

1- Number of branches /plant.

2- Number of pods /plant.

3- Seed weight /plant (gm).

4- 100-seed weight (gm).

5- Seed yield (ard/fad.) (ard =155kg).

6- Protein percentage (%) in seed: Nitrogen determination was carried out by the improved Kiel dhal method of [9] and calculated using the following equation:

Protein percentage = seed N% x 6.2.

The recorded data were statistically analyzed in SAS software [10] according to [11] using the computer MSTAT-C statistical analysis package by 12]. The least significant difference (Usual and Revised LSD) treatment at probability level at 0.05% was manually calculated to compare the differences between treatment means of the studied traits to [13].

3. Results and Discussion

The effect of humic acid rates and phosphorus fertilization levels on the yield of two faba bean varieties in the 2021/2022 and 2022/2023seasons in Tables (1-6). Data showed that the influence of the two faba bean varieties on number of branches/plant, number of pods/plant, seed weight/plant and protein content were significant in both seasons, while did not significantly differ between varieties in100-seed weight in both seasons. But, seeds were yielded significantly in the second season. Misr-1 variety had the highest values of Giza-843 for the number of branches /plant (10.31-14.02%), number of pods /plant (17.93and 20.66), seed weight /plant (6.71% and 3.21%) and protein content (25.43% and 25.74%) in the first and second seasons, respectively. But, seed yield (16.33%) in the second season. This shown difference between faba bean varieties plant may be due to the difference in the efficiency of photosynthesis and their content of internal hormones and genetic make-up and their environmental condition. The results were in agreement with [2,3,14,15,16,17].

The data presented found that the influence of phosphorus fertilization levels on all characteristics studied was significant in the first and second seasons. However, the highest values of all the characteristics studied were applied at a rate of 30kg P_2O_5/fad., during a growing season with significant differences in both seasons. The positive effect may be due to the role of phosphate fertilization in stimulating the formation of amino acids and growth hormones and cell division and enlargement and thus increases the efficiency of the root system. Therefore, the physiological activities of the plant are enhanced, leading to better yield. These results are in agreement with those obtained by [3,18,19,20,21,22,23,24,25].

Results showed that the influence of humic acid had a significant impact on all characteristics studied when added at a rate of 12 kg/fad., in the 2021-2022 and 2022-2023seasons. Was given the highest number of branches was by (27.64 and 24.45%), number of pods (20.19 and22.85), seed/weight plant (46.78and 51.73), 100-seed weight (80.99 and 87.49), seed yield/fad. (10.17and 11.51) and protein content in seeds (25.57and 25.80%) Comparison with control in the 2021-2022 and 2022–2023 seasons, respectively. The increase in seed yield/fad of faba bean in response to humic acid could be attributed to the role of the applied plant growth regulators in improving the nutrient uptake from the soil and subsequently increasing the plant growth by increasing the photosynthetic rate, which increased the number of branches, number of pods, seed weight, 100-seed weight, seed yield and protein content. These results are in harmony with those obtained by [2,15,26,27,28,29,30,31,32]. The interactions between varieties and phosphorus fertilization levels were significant in the number of branches in both seasons. But, there was significant in the number of pods, 100-seed weight and protein content in the second season only. As for the seed weight/plant in the first season. while, was not significantly in seed yield/fad. in both seasons.

Table 1: Influence of humic acid rates and phosphorus fertilization levels and their interaction on the number of branches/plant of two faba bean varieties in the 2021/2022 and 2022/2023 seasons

Seasons		2021/2022				2022/2023			
Varieties	P- rates (P_2o_5 kg/fed.)	Humic acid (H)				Humic acid (H)			
(V)	(P)	Without addition (Control)	6 kg/fad.	12kg/fad.	Mean	Without addition (Control)	6kg/fad.	12kg/fad.	Mean
Misr-1	15	4.137	4.372	4.788	4.432	4.182	4.897	5.005	4.694
	22.5	4.332	5.052	5.766	5.050	4.520	5.117	5.687	5.108
	30	4.799	5.475	5.976	5.416	4.866	5.544	5.954	5.455
Mean		4.423	4.966	5.510	4.966	4.523	5.186	5.549	5.086
Giza-843	15	3.380	4.449	4.961	4.264	3.403	4.402	4.815	4.206
	22.5	3.497	4.455	5.588	4.513	3.538	4.569	5.103	4.403
	30	3.536	4.568	5.649	4.584	3.617	4.544	5.370	4.510
Mean		3.471	4.491	5.399	4.454	3.519	4.505	5.096	4.373
Mean for P-rates	15	3.759	4.411	4.875	4.348	3.792	4.649	4.910	4.450
	22.5	3.915	4.753	5.677	4.782	4.029	4.843	5.395	4.756
	30	4.167	5.021	5.812	5.000	4.242	5.044	5.662	4.982
Mean		3.947	4.728	5.455		4.021	4.845	5.322	
Usual L.S.D. at 5% for :				Revised L.S.D. at 5% for :		Usual L.S.D. at 5% for :			Revised L.S.D. at 5% for :
Varieties (V)		0.03		0.06		Varieties (V)		0.02	0.09
phosphorus (P)		0.01		0.10		phosphorus (P)		0.03	0.05
Humic acid (H)		0.01		0.06		Humic acid (H)		0.02	0.04
V X P		0.02		0.10		V X P		0.04	0.05
V X H		0.02		0.06		V X H		0.03	0.04
P X H		0.02		0.04		P X H		0.03	0.03
V X P X H		0.03		0.04		V X P X H		0.05	0.03

Table 2: Influence of humic acid rates and phosphorus fertilization levels and their interaction on the number of pods/plant of two faba bean varieties in the 2021/2022 and 2022/2023 seasons

Seasons		2021/2022				2022/2023			
Varieties	P- rates (P_2O_5 kg/fed.)	Humic acid (H)				Humic acid (H)			
(V)	(P)	Without addition (Control)	6 kg/fad.	12kg/fad.	Mean	Without addition (Control)	6kg/fad.	12kg/fad.	Mean
Misr-1	15	13.02	16.94	20.16	16.71	16.29	20.13	21.80	19.41
	22.5	16.13	17.85	20.93	18.30	18.19	20.21	23.18	20.52
	30	15.77	19.42	21.12	18.77	18.59	23.29	24.30	22.06
Mean		14.97	18.07	20.74	17.93	17.69	21.21	23.09	20.66
Giza-843	15	11.74	16.84	19.19	15.92	17.14	19.53	22.15	19.61
	22.5	14.39	17.37	19.46	17.07	17.90	20.45	22.70	20.35
	30	15.93	17.71	20.25	17.97	18.09	21.66	22.99	20.91
Mean		14.02	17.31	19.63	16.99	17.71	20.55	22.61	20.29
Mean for P-rates	15	12.38	16.89	19.68	16.32	16.71	19.83	21.97	19.51
	22.5	15.26	17.61	20.20	17.69	18.05	20.33	22.94	20.44
	30	15.85	18.57	20.69	18.37	18.34	22.48	23.64	21.49
Mean		14.50	17.69	20.19		17.70	20.88	22.85	

Usual L.S.D. at 5% for :		Revised L.S.D. at 5% for :	Usual L.S.D. at 5% for :		Revised L.S.D. at 5% for :
Varieties (V)	0.41	0.70	Varieties (V)	0.26	0.64
phosphorus (P)	0.23	0.56	phosphorus (P)	0.20	0.62
Humic acid (H)	0.33	0.76	Humic acid (H)	0.27	0.61
V X P	N.S	N.S	V X P	0.34	0.49
V X H	N.S	N.S	V X H	N.S	N.S
P X H	0.57	0.81	P X H	0.46	0.95
V X P X H	0.99	0.91	V X P X H	N.S	N.S

Table 3: Influence of humic acid rates and phosphorus fertilization levels and their interaction on seed weight/plant (g) of two faba bean varieties in the 2021/2022 and 2022/2023 seasons

Seasons		2021/2022				2022/2023			
Varieties	P- rates (P_2o_5 kg/fed.)	Humic acid (H)				Humic acid (H)			
(V)	(P)	Without addition (Control)	6 kg/fad.	12kg/fad.	Mean	Without addition (Control)	6 kg/fad.	12kg/fad.	Mean
Misr-1	15	33.58	37.10	41.57	37.42	35.79	41.61	45.21	40.87
	22.5	35.01	43.06	50.51	42.86	38.61	46.51	54.58	46.57
	30	38.02	46.71	54.27	46.33	41.44	49.30	58.44	49.73
Mean		35.54	42.29	48.78	42.20	38.61	45.81	52.74	45.72
Giza-843	15	30.50	40.89	43.32	38.24	34.38	43.30	46.89	41.53
	22.5	31.78	42.04	44.90	39.57	35.03	46.06	51.73	44.27
	30	32.04	42.77	46.11	40.31	37.28	49.98	53.55	46.94
Mean		31.44	41.90	44.78	39.37	35.56	46.45	50.73	44.25
Mean for P-rates	15	32.04	39.00	42.45	37.83	35.09	42.46	46.05	41.20
	22.5	33.40	42.55	47.71	41.22	36.82	46.29	53.15	45.42
	30	35.03	44.74	50.19	43.32	39.36	49.64	56.00	48.33
Mean		33.49	42.09	46.78		37.09	46.13	51.73	
Usual L.S.D. at 5% for :				Revised L.S.D. at 5% for :		Usual L.S.D. at 5% for :			Revised L.S.D. at 5% for :
Varieties (V)		0.74		1.27		Varieties (V)	0.93		1.44
phosphorus (P)		0.52		1.25		phosphorus (P)	0.53		1.00
Humic acid (H)		0.32		1.06		Humic acid (H)	0.51		1.19
V X P		0.90		1.77		V X P	N.S		N.S
V X H		0.56		1.06		V X H	0.89		1.01
P X H		0.56		0.75		P X H	0.89		1.22
V X PX H		0.96		0.77		V X P X H	1.54		1.31

Table 4: Influence of humic acid rates and phosphorus fertilization levels and their interaction on the 100-seed weight (g) of two faba bean varieties in the 2021/2022 and 2022/2023 seasons

Seasons		2021/2022				2022/2023			
Varieties	P- rates (P_2o_5 kg/fed.)	Humic acid (H)				Humic acid (H)			
(V)	(P)	Without addition (Control)	6 kg/fad.	12kg/fad.	Mean	Without addition (Control)	6 kg/fad.	12kg/fad.	Mean
Misr-1	15	69.82	73.47	75.79	73.03	70.40	79.74	82.38	77.51
	22.5	71.45	76.73	81.76	76.65	72.16	83.04	87.62	80.94
	30	71.22	81.88	85.08	79.39	76.55	85.33	91.46	84.45
Mean		70.83	77.36	80.88	76.36	73.04	82.70	87.15	80.97
Giza-843	15	66.07	72.19	76.56	71.61	72.23	81.86	84.76	79.62
	22.5	67.45	80.03	82.20	76.56	74.33	84.11	87.93	82.12
	30	69.76	81.69	84.56	78.67	77.81	87.60	90.80	85.40
Mean		67.76	77.97	81.10	75.61	74.79	84.52	87.83	82.38
Mean for P-rates	15	67.95	72.83	76.18	72.32	71.32	80.80	83.57	78.56
	22.5	69.45	78.38	81.98	76.60	73.25	83.57	87.78	81.53
	30	70.49	81.78	84.82	79.03	77.18	86.47	91.13	84.93
Mean		69.30	77.66	80.99		73.92	83.61	87.49	

Usual L.S.D. at 5% for :		Revised L.S.D. at 5% for :	Usual L.S.D. at 5% for :		Revised L.S.D. at 5% for :
Varieties (V)	N.S	N.S	Varieties (V)	N.S	N.S
phosphorus (P)	0.34	0.82	phosphorus (P)	0.88	2.07
Humic acid (H)	0.47	1.51	Humic acid (H)	0.53	1.74
V X P	N.S	N.S	V X P	0.59	1.22
V X H	N.S	N.S	V X H	0.82	1.55
P X H	0.82	1.10	P X H	0.92	1.48
V X PX H	N.S	N.S	V X PX H	1.42	1.20

Table 5: Influence of humic acid rates and phosphorus fertilization levels and their interaction on seed yield (ard./fad.) of two faba bean varieties in the 2021/2022 and 2022/2023 seasons

Seasons		2021/2022				2022/2023			
Varieties	P-rates (P_2O_5 kg/fed.)	Humic acid (H)				Humic acid (H)			
(V)	(P)	Without addition (Control)	6 kg/fad.	12kg/fad.	Mean	Without addition (Control)	6 kg/fad.	12kg/fad.	Mean
Misr-1	15	7.318	9.218	10.24	8.926	9.909	11.15	12.51	11.19
	22.5	7.289	8.099	10.14	8.508	10.24	11.21	12.23	11.23
	30	7.241	9.304	10.67	9.070	10.66	11.42	13.14	11.74
Mean		7.282	8.874	10.35	8.835	10.27	11.26	12.63	11.39
Giza-843	15	7.129	9.355	9.802	8.762	8.047	9.514	10.18	9.248
	22.5	7.255	8.095	10.04	8.463	8.237	10.06	10.47	9.590
	30	8.245	8.809	10.13	9.060	8.426	10.28	10.54	9.749
Mean		7.543	8.753	9.990	8.762	8.237	9.951	10.40	9.529
Mean for P-rates	15	7.224	9.287	10.02	8.844	8.978	10.33	11.35	10.22
	22.5	7.272	8.097	10.09	8.486	9.239	10.64	11.35	10.41
	30	7.743	9.056	10.40	9.065	9.545	10.85	11.84	10.74
Mean		7.413	8.813	10.17		9.254	10.61	11.51	

Usual L.S.D. at 5% for :		Revised L.S.D. at 5% for :		Usual L.S.D. at 5% for :		Revised L.S.D. at 5% for :
Varieties (V)	N.S	N.S		Varieties (V)	0.23	0.40
phosphorus (P)	0.09	0.21		phosphorus (P)	0.14	0.34
Humic acid (H)	0.07	0.18		Humic acid (H)	0.08	0.18
V X P	N.S	N.S		V X P	N.S	N.S
V X H	0.12	0.19		V X H	0.13	0.18
P X H	0.12	0.18		P X H	N.S	N.S
V X P X H	0.21	0.19		V X P X H	0.23	0.21

Table 6: Influence of humic acid rates and phosphorus fertilization levels and their interaction on protein content of two faba bean varieties in the 2021/2022 and 2022/2023 seasons

Seasons		2021/2022				2022/2023			
Varieties	P- rates (P_2o_5 kg/fed.)	Humic acid (H)				Humic acid (H)			
(V)	(P)	Without addition (Control)	6 kg/fad.	12kg/fad.	Mean	Without addition (Control)	6 kg/fad.	12kg/fad.	Mean
Misr-1	15	24.34	25.14	25.28	24.92	24.37	25.26	25.47	25.03
	22.5	25.18	25.44	25.81	25.48	25.38	25.47	26.46	25.77
	30	25.48	25.84	26.38	25.90	26.28	26.37	26.62	26.42
Mean		25.00	25.47	25.82	25.43	25.34	25.70	26.19	25.74
Giza-843	15	24.15	24.43	24.77	24.45	24.24	24.78	24.84	24.62
	22.5	24.17	25.13	25.46	24.92	24.34	25.54	25.47	25.12
	30	25.16	25.68	25.75	25.53	24.87	25.64	25.95	25.49
Mean		24.49	25.08	25.32	24.97	24.48	25.32	25.42	25.07
Mean for P-rates	15	24.24	24.79	25.02	24.68	24.31	25.02	25.16	24.83
	22.5	24.68	25.29	25.64	25.20	24.86	25.51	25.97	25.44
	30	25.32	25.76	26.07	25.71	25.57	26.00	26.29	25.95
Mean		24.75	25.28	25.57		24.91	25.51	25.80	

Usual L.S.D. at 5% for :		Revised L.S.D. at 5% for :	Usual L.S.D. at 5% for :		Revised L.S.D. at 5% for :
Varieties (V)	0.24	0.51	Varieties (V)	0.03	0.06
phosphorus (P)	0.10	0.30	phosphorus (P)	0.05	0.21
Humic acid (H)	0.13	0.41	Humic acid (H)	0.18	0.61
V X P	N.S	N.S	V X P	0.09	0.21
V X H	N.S	N.S	V X H	N.S	N.S
P X H	N.S	N.S	P X H	N.S	N.S
V X P X H	0.39	0.34	V X P X H	0.55	0.63

The interactions between varieties and humic acid were significant in both seasons for all characteristics studied, except 100-seed weight in the second season and there was no significant in the number of pods and protein content in both seasons, respectively. The interaction effect between phosphorus fertilization levels and humic acid was significant in the first and second seasons for all studied attributes, except seed yield/fad. in the first season only. While there was no significant protein content in both seasons. The effect of the interaction among three factors: varieties x phosphorus fertilization levels x humic acid was significant for all studied traits in both seasons, except the number of pods/plant in the first season. While 100-seed weight in the second season only.

4. Conclusions

One of the most important parameters that affect the productivity and quality of faba bean is phosphate fertilization levels and humic acid. The results showed that faba bean plants increasing the rates of humic acid and phosphate fertilization lead to a significant increase in the number of branches/plant, number of pods/plant, seed weight/plant, 100-seed weight, seed yield and protein content. There were significant differences among faba bean varieties for all the traits studied. Phosphate fertilization is significantly affected by all the previous characters. The highest values for all studies characters resulted from using 30kgP_2O_5/fad. Comparison of other phosphate fertilization treatments in both seasons. Humic acid levels showed significant differences in all character studies. The highest values resulting from the treatment when adding 12 kg of humic acid/fad. and 30 kg of P_2O_5/fad. for the Misr-1 variety.

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