Nativa, Sinop, v. 11, n. 3, p. 408-421, 2023.
Pesquisas Agrárias e Ambientais
DOI: https://doi.org/10.31413/nativa.v11i3.16181
ISSN: 2318-7670

Broad bean (*Vicia faba* L.) crop growth and yield response to humic acid and phosphorus fertilizer

Ahmed Jomaa Ahmed AL-AZEE [1], Ali Hussein RAHEEM [1*], Kareem Saaid Azeez AL-OBAIDY [2]

[1]Field Crops Department, College of Agriculture, University of Kirkuk, Kirkuk, Iraq.
[2] Soil Science and Water Resources Department, College of Agriculture, University of Kirkuk, Kirkuk, Iraq.
*E- mail: ahraldawodi@uokirkuk.edu.iq

Submitted on 03/07/2023; Accepted on 05/13/2023; Published on 09/22/2023.

ABSTRACT: A field experiment was conducted during the winter growing season in the field of the directorate of agriculture in Kirkuk Governorate, Iraq to investigate the two broad bean cultivars (Fava da Orto and Luz de Otono) crop growth and yield response to three levels of humic acid (0, 20 and 40 kg ha^{-1} Potassium humate) as soil application and three phosphorus fertilizer levels (80,120 and 160 kg P_2O_5 ha^{-1}). A randomized complete block design (RCBD) with three replications was used in this experiment laid out. The results showed that the two cultivars did not differ significantly in most of the studied traits, Luz de Otono cultivar is significantly superior in the leaf content of chlorophyll a and b, while the Fava da Orto cultivar is significantly superior in plant seed yield. An increasing application of humic acid up to 40 kg ha^{-1} Potassium humate and phosphorus fertilizer levels up to 160 kg P_2O_5 ha^{-1} significantly reduced the number of days to 50% flowering and first pod appearance. In contrast, significantly increased leaf area and leaf area index, leaves the content of chlorophyll a, b and total, plant dry matter, leaves nitrogen and phosphorus percentage, pod length, plant seed yield, seeds nitrogen and phosphorus percentage and seeds protein percentage. Binary interaction between Fava da Orto cultivar with 40 kg ha^{-1} Potassium humate and 160 kg P_2O_5 ha^{-1}, 40 kg ha^{-1} Potassium humate with 160 kg P_2O_5 ha^{-1} and triple interaction among Fava da Orto cultivar, 40 kg ha^{-1} Potassium humate and 160 kg P_2O_5 ha^{-1} significantly gave the highest value in most of the studied traits, especially plant seed yield and seeds protein percentage. We can conclude that crop growth and seed yield for two tested broad bean cultivars were a high response to the high levels of humic acid and phosphorus fertilizer used in this study at the experiment location due to the low soil content in organic matter and mineral elements.
Keywords: Faba bean cultivars; organic fertilization; phosphate fertilization.

Crescimento da cultura de fava (*Vicia faba* L.) e resposta da produtividade ao ácido húmico e fertilizante fosfatado

RESUMO: Um experimento de campo foi conduzido durante a estação de cultivo de inverno no campo da diretoria de agricultura na província de Kirkuk, Iraque, para investigar o crescimento da cultura e a resposta do rendimento de duas cultivares de fava (Fava da Orto e Luz de Otono) a três níveis de ácido húmico (0, 20 e 40 kg ha^{-1} Humato de potássio) como aplicação no solo e três níveis de fertilizante fosfatado (80,120 e 160 kg P_2O_5 ha^{-1}). Neste experimento foi utilizado um delineamento em blocos completos casualizados (RCBD) com três repetições. Os resultados mostraram que as duas cultivares não diferiram significativamente na maioria das características estudadas, a cultivar Luz de Otono é significativamente superior no teor foliar de clorofila aeb, enquanto a cultivar Fava da Orto é significativamente superior no rendimento de sementes das plantas. Uma aplicação crescente de ácido húmico até 40 kg ha^{-1} Os níveis de humato de potássio e fertilizantes fosfatados até 160 kg P_2O_5 ha^{-1} reduziram significativamente o número de dias para 50% da floração e do aparecimento da primeira vagem, enquanto aumentaram significativamente a área foliar e a área foliar índice, teor de clorofila a, b e total nas folhas, matéria seca da planta, porcentagem de nitrogênio e fósforo nas folhas, comprimento das vagens, produtividade de sementes das plantas, porcentagem de nitrogênio e fósforo nas sementes e porcentagem de proteína nas sementes. Interação binária entre a cultivar Fava da Orto com 40 kg ha^{-1} de humato de potássio e 160 kg de P_2O_5 ha^{-1}, 40 kg ha^{-1} Humato de potássio com 160 kg de P_2O_5 ha^{-1} e tripla interação entre a cultivar Fava da Orto, 40 kg ha^{-1} Humato de potássio e 160 kg P_2O_5 ha^{-1} proporcionaram significativamente os valores mais elevados na maioria das características estudadas, especialmente no rendimento de sementes e na porcentagem de proteína das sementes. Podemos concluir que o crescimento da cultura e a produção de sementes para duas cultivares de fava testadas foram uma resposta elevada aos altos níveis de ácido húmico e fertilizante fosfatado utilizados neste estudo no local do experimento, devido ao baixo teor de matéria orgânica e elementos minerais do solo.
Palavras-chave: cultivares de Fava; fertilização orgânica; fertilização fosfatada.

1. INTRODUCTION

Broad bean (*Vicia faba* L.), which belongs to the Fabaceae family, is considered one of the important components in the global food production system because it is one of the most consumed crops in its season in the form of green pods, green and dry seeds and it is a cheap source of protein especially for poor peoples (ALSAWAF; IBRAHEEM, 2023). The broad bean crop in Iraq is widely grown in winter for human consumption, using its green pods and green and dry seeds in cooking (ALRAWI et al., 2023). In Kirkuk Governorate, broad bean is considered the first pulses crop in terms of cultivation area and productivity.

To achieve the highest yield and increase production efficiency, good cultivars should be cultivated with high yields and good quality appropriate to the conditions of the agriculture area (ABDEL NABI; OBAID, 2019). Increasing broad bean yield per unit area can be achieved by sowing high-yielding cultivars. The genetics installation of cultivated cultivars plays an important role in expressing itself in different agricultural environments (EMAM; SEMIDA, 2020), so two cultivars of imported commercial broad beans were chosen to determine their growth and productivity under Kirkuk Governorate, Iraq conditions. Abd Alqader et al. (2020) found significant differences between the two broad bean cultivars in leaf area, leaves total chlorophyll content and pod length. Significant differences in days to 50% flowering and leaves chlorophyll index (SPAD) among three broad bean genotypes were reported by (SALEH 2020). ABED et al. (2021) stated that broad bean cultivars showed highly significant variation in leaf area and plant seed yield.

Humic acid is a commercial product containing many elements that improve soil fertility, plant growth and yield. Humic acid is one of the used as organic and mineral fertilizers and it has been shown to stimulate plant growth and increase plant yield; the humic acid matter is produced by the chemical and biological decomposition of organic material (ABO-HEGAZY and BADAWY, 2022). AL-OBAIDI (2020) significantly increased broad bean plant leaf area, leaf area index, leaves total chlorophyll content, pod length and plant seed yield when using 4 kg ha^{-1} humic acid compared with zero and 2 kg ha^{-1} humic acid. MAHDI et al. (2021) found that soil application of humic acid with 50 kg ha^{-1} Potassium humate significantly increased leaf content of chlorophyll a and b, leaves N and P content, plant dry matter and seed yield compared to control treatment.

A suitable combination of organic and inorganic sources of fertilizers is necessary for sustainable crop yield (AWAAD et al., 2020). Integrating organic fertilizers such as humic acid with inorganic fertilizers such as phosphorus has become imperative for sustained broad bean crop growth and yield. Farid et al. (2021) mentioned that combinations between humic acid and mineral fertilizer are assumed to retain higher available nutrients in soil than those obtained for the sole application of either mineral or organic applications.

These combinations can be used for Iraqi soils that tend to be alkaline, which causes fixation of most of the phosphorus fertilizers application. So, applying organic fertilizers such as humic acid can increase soil phosphorus availability and crop absorption. Adding phosphorus to soil is a very important process for pulses crops, where it is considered the most important nutrient limiting pulse growth and yield (EL-KHOLY et al., 2019). Pulses have a relatively high phosphorus requirement and are particularly sensitive to phosphorus deficiency (SARKAR et al., 2017).

The crop's good growth is related to the availability of important nutrients; phosphorus is one of the essential nutrients for plant nutrition and plays an important role in the plant's physiological processes and enzymatic reactions (JASIM; ALGHREBAWI, 2020). Jasim; Al-Amiri (2020) pointed out that adding phosphorus fertilizer up to 240 kg $P_2O_5.ha^{-1}$ with foliar spraying of humic acid up to 3000 mg L^{-1} caused an enhancement in plant growth and increased broad bean seed yield. Jasim; Alghrebawi (2020) concluded that applying phosphorus fertilizer with humic acid positively reflected vegetative growth traits and increased the broad bean seed yield.

The major objective of this work was to investigate the response of two broad bean cultivars to humic acid and phosphorus fertilizer application to improve the growth and yield of broad bean plants under area study conditions of Kirkuk Governorate, Iraq.

2. MATERIAL AND METHODS

2.1. Experimental area, soil analysis and weather conditions

The field experiment was conducted during the winter growing season of 2017-2018 in Kirkuk district center, Kirkuk Governorate, Iraq (35° 28′ N, 44° 19′ E, altitudes 331m) under supplementary irrigation. Soil samples were taken at a depth of 0-30 cm before sowing from different areas of the experimental field and tested in the laboratory of the directorate of agriculture of Kirkuk. Soil properties are listed in Table 1. Monthly mean temperature, relative humidity and rainfall are listed in Table 2. Data was obtained from the Iraqi Meteorological Authority, Baghdad, Iraq.

Table 1. Soil properties for the experimental site.
Tabela 1. Propriedades do solo do local experimental.

Physical properties	Value
Sand (%)	41
Clay (%)	34
Silt (%)	25
Soil texture	Silty clay
Chemical properties	
PH	7.7
Ec (ds m^{-1})	2.1
Organic matter (%)	0.99
Available Nitrogen (mg kg^{-1})	2.95
Available Phosphorus (mg kg^{-1})	7.9
Available Potassium (mg kg^{-1})	40
Soil Porosity (%)	38.7

Table 2. Maximum and minimum monthly temperature (C°), relative humidity (%) and rainfall (mm) for the experimental site.
Tabela 2. Temperatura máxima e mínima mensal (C°), umidade relativa (%) e precipitação (mm) para o local experimental.

Month	Temperature		Relative humidity	Rainfall
	maximum	minimum		
November	24.6	10.3	58	2.3
December	20.6	9.0	69	11.1
January	17.2	3.5	78	23.7
February	17.8	8.5	68	155.3
March	24.6	13.4	49	7.5
April	28.1	15.5	51	41.1

2.2. Experimental design and treatments

The experiment included two imported commercial broad bean cultivars, namely Fava da Orto (French) and Luz de Otono (Spanish), obtained from local markets, with three levels of humic acid (0, 20 and 40 kg ha^{-1} Potassium humate). Their components are listed in Table 3, and three phosphorus fertilizer levels (80,120 and 160 kg P_2O_5 ha^{-1}). Two soil sprays of humic acid were applied, the first after 40 days from the sowing date and the second after a month of first spraying. Super triphosphate (46% P_2O_5) is used as a phosphorus fertilizer source in one batch before sowing. The experiment was conducted in a randomized complete block design (RCBD) with three replications.

Table 3. Components of Potassium humate (w/w).
Tabela 3. Componentes do Humato de Potássio (p/p).

Components	Value
Moisture (%)	10-12
Decomposition (%)	99.8
Potassium humate (%)	85
Potassium soluble in water (K_2O) (%)	11
Water insoluble (%)	< 0.1
Dry matter (%)	88-90
Nitrogen (%)	0.8
Iron (%)	1
Other materials (%)	15
Cation exchange	> 400 meq $100g^{-1}$

2.3. Agricultural practices

After preparing the land of the experiment by tillage, smoothing and leveling, it was divided into experimental units. Broad bean seeds were sowed on 7 Nov. by putting 2-3 seeds in each hill on the rows and then thinned into one plant for each hill a month after showing the g date. Each experimental unit included five rows with 3m along, 0.6m between rows and 0.25m between hills. Urea fertilizer (46% N) was added with an amount of 180 kg N ha^{-1} in two equal batches, the first at sowing time and the second at the flowering stage. Weed management was carried out by hoeing twice during the growing season.

2.4. Data collection

Data were collected on days to 50% flowering and the first pod appearance for middle rows for each plot, random samples of five broad bean plants were taken from middle rows for each experimental unit to determine the leaf area ($cm^2.plant^{-1}$), which was taken at the flowering stage by Watson (1958) method's, leaf area index, leaves chlorophyll content a, b and total assessed by Machinny (1941) method's, plant dry matter yield (g $plant^{-1}$), leaves nitrogen percentage (%) was assessed according to A.O.A.C. (1980), leaves phosphorus percentage (%) was assessed by Estefan et al. (2013) method's, pod length (cm), plant dry seed yield ($g.plant^{-1}$), seeds nitrogen percentage (%) was assessed according to A.O.A.C. (1980), seeds phosphorus percentage (%) was assessed by Estefan et al. (2013) method's and seeds protein percentage (%) was assessed according to A.O.A.C. (1980).

2.5. Statistical analysis

Statistical analysis was carried out for all traits that were studied according to analysis of variance. Duncan's multiple range test at 0.05 probability was used to detect the significant differences between the means. SAS-V9 (2002) statistical analysis program was used to do statistical analysis.

3. RESULTS

3.1. Days to 50% flowering and first pod appearance

Tables 4 and 5 shows that the two broad bean cultivars did not differ significantly in days to 50% flowering and first pod appearance. There were significant differences among humic acid levels. A high level of humic acid 40 kg ha^{-1} Potassium humate caused significant earliness in flowering (66.7 days) and first pod appearance (111.1 days) compared to control treatment and 20 kg ha^{-1} potassium humate application. This may be due to the role of humic acid in increasing phosphorus availability in soil, which has a vital role in earliness flowering and earliness in the first pod appearance. A high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} caused a significant earliness in days to 50% flowering (65.7 days) and first pod appearance (112.0 days) compared to another level of phosphorus fertilizer. This is due to the role of phosphorus in enhancing flowering and increasing crop development rate, which resulted in decreasing the days to 50% flowering and first pod appearance compared to low levels of phosphorus fertilizer; these findings agreed with Hailu; Ayle (2019) and Hailu et al. (2019) they found that high level of phosphorus fertilizer significantly caused an earliness in the flowering of broad bean plants.

3.2. Leaf Area and Leaf Area Index

The results in Tables 6 and 7 shows that the two broad bean cultivars did not differ significantly in leaf area and leaf area index.

Table 4. Effect of cultivars, humic acid, phosphorus and interactions on days to 50% flowering of broad bean.
Tabela 4. Efeito de cultivares, ácido húmico, fósforo e interações nos dias para 50% de florescimento da fava.

Cultivars	Humic acid (kg ha^{-1})	Phosphorus (kgP_2O_5 ha^{-1}) 80	120	160	Cultivars × Humic acid
Fava da Orto	0	78.3 a	77.7 ab	65.7 g	73.9 a
	20	75.7 bc	72.7 de	66.0 g	71.4 b
	40	69.3 f	64.7 g	64.3 g	66.1 c
Luz de Otono	0	78.0 ab	77.7 ab	66.0 g	73.9 a
	20	74.0 cd	72.7 de	66.7 g	71.1 b
	40	70.3 of	66.0 g	65.3 g	67.2 c
Phosphorus average		74.3 a	71.9 b	65.7 c	
Cultivars × Phosphorus					Cultivars average
Fava da Orto		74.4 a	71.7 b	65.3 c	70.5 a
Luz de Otono		74.1 a	72.1 b	66.0 c	70.8 a
Humic acid × Phosphorus					Humic acid average
0		78.2 a	77.7 a	65.8 e	73.9 a
20		74.8 b	72.7 c	66.3 e	71.3 b
40		69.8 d	65.3 e	64.8 e	66.7 c

The values followed with different letters significantly differ for each other according to Duncan multiple range test at 0.05 probability level.

3.3. Leaves content of chlorophyll a, b and total

Tables 8, 9 and 10 show that the Luz de Otono cultivar significantly exceeded the Fava da Orto cultivar in leaf content of chlorophyll a and b (3.99 and 1.93 mg g^{-1} F.W.), respectively, but the two broad bean cultivars did not differ significantly in leaves content of total chlorophyll. The reason for differences between the two cultivars in leaf content of chlorophyll a and b may be due to the variation in the genotypes of the cultivars in their genetic composition, the nature of their growth, which potential to withstand the environmental conditions in the cultivation location, and the variation in genetic effect of the tested broad bean cultivars translated into different physiological traits of broad bean cultivars leaves the content of photosynthetic pigments.

These results agree with Emam; Semida (2020) and with Saleh; Saleh (2020) they found that broad bean cultivars significantly differed in photosynthetic pigments. Concerning the humic acid effect, the results indicated that the content of chlorophyll a, b and total significantly increased with an increasing humic acid level, where a high level of humic acid 40 kg ha^{-1} potassium humate significantly gave the highest average in leaves content of chlorophyll a, b and total (5.15, 2.66 and 7.82 mg g^{-1} F.W.), respectively compared to control treatment which gave the lowest average (2.88, 1.46 and 4.06 mg g^{-1} F.W.), respectively.

Table 5. Effect of cultivars, humic acid, phosphorus and interaction on days to first pod appearance of broad bean.
Tabela 5. Efeito de cultivares, ácido húmico, fósforo e interação nos dias para aparecimento da primeira vagem da fava.

Cultivars	Humic acid (kg ha^{-1})	Phosphorus (kgP$_2$O$_5$ ha^{-1}) 80	120	160	Cultivars × Humic acid
Fava da Orto	0	116.7 a	115.7 abc	114.7 bcd	115.7 a
	20	113.3 d-g	112.7 d-g	111.7 hi	112.7 b
	40	111.3 i	111.7 hi	109.3 j	110.8 c
Luz de Otono	0	116.0 ab	115.3 abc	114.3 cde	115.2 a
	20	113.7 def	113.0 d-i	112.3 f-i	113.0 b
	40	112.0 ghi	112.3 f-i	109.7 j	111.3 c
Phosphorus average		113.8 a	113.4 a	112.0 b	
		Cultivars × Phosphorus			Cultivars average
Fava da Orto		113.8 a	113.3 a	111.9 b	113.0 a
Luz de Otono		113.9 a	113.6 a	112.1 b	113.2 a
		Humic acid × Phosphorus			Humic acid average
0		116.3 a	115.5 ab	114.5 bc	115.4 a
20		113.5 cd	112.8 de	112.0 of	112.8 b
40		111.7 f	112.0 fe	109.5 g	111.1c

The values followed with different letters significantly differ for each other according to Duncan multiple range test at 0.05 probability level.

Table 6. Effect of cultivars, humic acid, phosphorus and interactions on broad bean leaf area (cm2 plant-1).
Tabela 6. Efeito de cultivares, ácido húmico, fósforo e interações na área foliar (cm² plant^{-1}) da fava.

Cultivars	Humic acid (kg ha^{-1})	Phosphorus (kgP$_2$O$_5$ ha^{-1}) 80	120	160	Cultivars × Humic acid
Fava da Orto	0	1319.3 h	1476.3 e-h	1690.1 a-d	1495.2 b
	20	1620.1 b-f	1741.5 a-d	1695.9 a-d	1685.8 a
	40	1432.2 fgh	1775.8 abc	1866.8 a	1691.6 a
Luz de Otono	0	116.0 ab	115.3 abc	114.3 cde	115.2 a
	20	113.7 def	113.0 d-i	112.3 f-i	113.0 b
	40	112.0 ghi	112.3 f-i	109.7 j	111.3 c
Phosphorus average		1450.1 b	1659.8 a	1710.1 a	
		Cultivars × Phosphorus			Cultivars average
Fava da Orto		1457.2 b	1664.5 a	1750.9 a	1624.2 a
Luz de Otono		1442.9 b	1655.1 a	1669.4 a	1589.1 a
		Humic acid × Phosphorus			Humic acid average
0		1321.9 d	1444.5 d	1623.0 c	1463.1 b
20		1603.6 b	1774.6 a	1675.1 bc	1684.5 a
40		1424.6 d	1760.3 ab	1832.3 a	1672.4 a

The values followed with different letters significantly differ for each other according to Duncan multiple range test at 0.05 probability level.

Table 7. Effect of cultivars, humic acid, phosphorus and interaction on broad bean leaf area index.
Tabela 7. Efeito de cultivares, ácido húmico, fósforo e interações no índice de área foliar da fava.

Cultivars	Humic acid (kg ha^{-1})	Phosphorus (kgP$_2$O$_5$ ha^{-1}) 80	120	160	Cultivars × Humic acid
Fava da Orto	0	0.88 h	0.98 e-h	1.13 a-d	1.00 b
	20	1.08 b-f	1.16 a-d	1.13 a-d	1.12 a
	40	0.95 fgh	1.18 abc	1.24 a	1.13 a
Luz de Otono	0	0.88 h	0.94 h	1.04 d-g	0.95 b
	20	1.06 c-g	1.21 ab	1.10 b-f	1.12 a
	40	0.94 fgh	1.16 a-d	1.20 ab	1.10 a
Phosphorus average		0.97 b	1.11 a	1.14 a	
		Cultivars × Phosphorus			Cultivars average
Fava da Orto		0.97 b	1.11 a	1.17 a	1.08 a
Luz de Otono		0.96 b	1.10 a	1.11 a	1.06 a
		Humic acid × Phosphorus			Humic acid average
0		0.88 d	0.96 d	1.08 c	0.98 b
20		1.07 b	1.18 a	1.12 bc	1.12 a
40		0.95 d	1.17 ab	1.22 a	1.11 a

The values followed with different letters significantly differ for each other according to Duncan multiple range test at 0.05 probability level.

Table 8. Effect of cultivars, humic acid, phosphorus and interactions on leaves chlorophyll a content (mg g-1 F.W.) of broad bean.
Tabela 8. Efeito de cultivares, ácido húmico, fósforo e interações no teor de clorofila a foliar (mg g-1 F.W.) de fava.

Cultivars	Humic acid (kg ha-1)	Phosphorus (kgP_2O_5 ha-1) 80	120	160	Cultivars × Humic acid
Fava da Orto	0	2.51 g	2.68 g	3.38 b-e	2.86 c
	20	3.21 f	3.80 dfe	4.17 bc	3.73 b
	40	3.81 b-e	5.07 bc	6.37 a	5.08 a
Luz de Otono	0	2.56 g	2.74 g	3.36 bcd	2.89 c
	20	3.28 of	3.85 cde	4.40 bc	3.84 b
	40	3.95 b-e	5.26 b	6.42 a	5.21 a
Phosphorus average					
	Cultivars × Phosphorus				Cultivars average
Fava da Orto		3.18 c	3.81 b	4.64 a	3.89 b
Luz de Otono		3.27 c	3.95 b	4.73 a	3.99 a
	Humic acid × Phosphorus				Humic acid average
0		2.55 f	2.71 of	3.37 de	2.88 c
20		3.25 def	3.82 cd	4.29 c	3.79 b
40		3.88 cd	5.16 b	6.40 a	5.15 a

The values followed with different letters significantly differ for each other according to Duncan multiple range test at 0.05 probability level.

Table 9. Effect of cultivars, humic acid, phosphorus and interactions on leaves chlorophyll b content (mg g-1 F.W.) of broad bean.
Tabela 9. Efeito de cultivares, ácido húmico, fósforo e interações no teor de clorofila b foliar (mg g-1 F.W.) de fava.

Cultivars	Humic acid (kg ha-1)	Phosphorus (kgP_2O_5 ha-1) 80	120	160	Cultivars × Humic acid
Fava da Orto	0	0.87 j	1.11 hi	1.43 g	1.13 d
	20	1.48 fg	1.72 efg	2.02 de	1.74 c
	40	2.20 cd	2.63 b	2.97 a	2.60 b
Luz de Otono	0	0.97 ij	1.20 h	1.52 fg	1.23 d
	20	1.57 fg	1.81 def	2.10 cd	1.84 c
	40	2.32 bc	2.74 b	3.12 a	2.72 a
Phosphorus average		1.57 c	1.87 b	2.19 a	
	Cultivars × Phosphorus				Cultivars average
Fava da Orto		1.52 d	1.82 c	2.13 b	1.83 b
Luz de Otono		1.62 d	1.91 c	2.26 a	1.93 a
	Humic acid × Phosphorus				Humic acid average
0		0.92 h	1.16 g	1.46 f	1.18 c
20		1.52 f	1.77 e	2.08 d	1.78 b
40		2.26 c	2.68 b	3.05 a	2.66 a

The values followed with different letters significantly differ for each other according to Duncan multiple range test at 0.05 probability level.

Table 10. Effect of cultivars, humic acid, phosphorus and interactions on leaves total chlorophyll content (mg g-1 F.W.) of broad bean.
Tabela 10. Efeito de cultivares, ácido húmico, fósforo e interações no teor de conteúdo total de clorofila (mg g-1 F.W.) de fava.

Cultivars	Humic acid (kg ha-1)	Phosphorus (kgP_2O_5 ha-1) 80	120	160	Cultivars × Humic acid
Fava da Orto	0	3.38 j	3.79 hi	4.81 g	3.99 c
	20	4.69 fg	5.52 efg	6.19 de	5.47 b
	40	6.01 cd	7.70 b	9.34 a	7.68 a
Luz de Otono	0	3.53 ij	3.94 h	4.88 fg	4.12 c
	20	4.85 fg	5.66 def	6.50 cd	5.67 b
	40	6.27 d	8.0 bc	9.54 a	7.94 a
Phosphorus average		4.79 c	5.77 b	6.87 a	
	Cultivars × Phosphorus				Cultivars average
Fava da Orto		4.70 c	5.67 b	6.78 a	5.72 a
Luz de Otono		4.89 c	5.87 b	6.99 a	5.92 a
	Humic acid × Phosphorus				Humic acid average
0		3.47 f	3.87 f	4.83 e	4.06 c
20		4.77 e	5.59 d	6.37 c	5.58 b
40		6.14 cd	7.85 b	9.45 a	7.82 a

The values followed with different letters significantly differ for each other according to Duncan multiple range test at 0.05 probability level.

3.4. Plant dry matter yield

The presented data in Table 11 shows no significant differences between the two broad bean cultivars in their plant dry matter yield. At the same time, humic acid levels have a significant effect on broad bean plant dry matter yield; the highest average of plant dry matter yield was obtained from the application of a high level of humic acid 40 kg ha-1 potassium humate (86.5 g plant-1) compared to without humic acid application treatment which gave the lowest average in plant dry matter yield (76.5 g plant-1). This result may be due to the role of humic acid in improving all growth traits of broad bean crop like leaf area and leaves content of chlorophyll, compared to unused humic acid treatment, where humic acid contain many elements (Table 3) required to improve plant growth, stimulate growth and enhance photosynthesis through increase photosynthetic pigments and accelerate cells division and elongation, all this positively reflected on increasing plant growth and then plant accumulation dry matter. Also, humic acid is considered a plant growth hormone that improves nutrient status and promotes plant growth of broad beans, humic acid causes an increase in nutritional elements in rooting zoon and increases the availability of nutrients consequently, the more nutrients are absorbed, so more enhancement of plant growth (Awaad et al., 2020) and resulted in more accumulation of dry matter and increasing plant dry matter yield in the end. The findings align with Al-Zubaidy; Al-Bawee (2018) and Mahdi et al. (2021).

3.5. Leaves nitrogen and phosphorus percentage

The data in Tables 12 and 13 indicates non-significant differences between the two broad bean cultivars in leaves N and P percentage, but leaves N and P percentage significantly increased with increasing humic acid levels, a high level of humic acid 40 kg ha^{-1} potassium humate significantly gave a highest average in leaves N and P percentage (4.90 and 0.283 %), respectively compared to zero humic acid level which gave a lowest average in leaves N and P percentage (3.11 and 0.250 %), respectively. These results are due to the role of humic acid substances, which play a prominent role in nutrient uptake, react with the cell membrane structures, and interact as a carrier of nutrients (MAHDI et al., 2021). Humic acid is the source of plant nutrients (Table 3) essential for plant growth such as N and P, the uptake of humic acid increases nutrient uptake and thus stimulates the growth of roots and whole plant (Abd-Elaziz et al., 2019) and then reflected on the shoot mineral elements contain. The simulative effect of humic acid on macronutrients N and P in broad bean leaves was also obtained by Fouda (2017) and Mahdi et al. (2021).

3.6. Pod length (cm)

The results in Table 14 show that the two broad bean cultivars significantly differed in pod length, Luz de Otono cultivar significantly gave a longer pod (21.3 cm), while Fava da Orto cultivar gave a shorter pod (19.8 cm). Abd Alqader et al. (2020) found similar results and reported that broad bean cultivars significantly differed in pod length.

Humic acid application caused a significant effect on pod length, where pod length significantly increased with increasing humic acid levels and a high level of humic acid 40 kg ha^{-1} Potassium humate gave a longer pod (21.9 cm) compared to the control treatment, which gave a shorter pod (18.7 cm). AL-Zubaidy reported the role of humic acid in increasing broad bean pod length; Al-Bawee (2018) and Al-Obaidi (2020). In respect to phosphorus fertilizer, the data shows that a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave a longer pod (22.4 cm) compared to 80 and 120 kg P_2O_5.ha^{-1} which gave a shorter pod (19.4 and 19.9 cm), respectively. The role of phosphorus in increasing broad bean pod length was noticed by Sarkar et al. (2017).

Table 11. Effect of cultivars, humic acid, phosphorus and interactions on broad bean plant dry matter yield (g plant-1).
Tabela 11. Efeito de cultivares, ácido húmico, fósforo e interações na produtividade de matéria seca da planta (g planta^{-1}) de fava.

Cultivars	Humic acid (kg ha^{-1})	Phosphorus (kgP_2O_5 ha^{-1}) 80	120	160	Cultivars × Humic acid
Fava da Orto	0	75.4 g	76.3 fg	78.7 def	76.8 c
	20	81.0 cde	80.5 cde	80.5 cde	80.7 b
	40	82.0 c	87.6 b	90.6 a	86.7 a
Luz de Otono	0	74.1 g	74.8 g	79.0 de	76.0 c
	20	78.6 of	81.3 cd	80.5 cde	80.0 b
	40	81.7 c	88.3 b	89.8 ab	86.8 a
Phosphorus average		78.8 c	81.3 b	83.1 a	
		Cultivars × Phosphorus			Cultivars average
Fava da Orto		79.5 c	81.3 b	83.2 a	81.3 a
Luz de Otono		78.6 c	81.1 b	82.9 a	80.7 a
		Humic acid × Phosphorus			Humic acid average
0		74.7 f	75.4 f	78.9 e	76.5 c
20		79.9 ed	80.1 cd	80.2 cde	80.2 b
40		81.9 c	87.6 b	90.1 a	86.5 a

The values followed with different letters significantly differ for each other according to Duncan multiple range test at 0.05 probability level.

Table 12. Effect of cultivars, humic acid, phosphorus and interactions on leaves nitrogen percentage (%) of broad bean.
Tabela 12. Efeito de cultivares, ácido húmico, fósforo e interações na porcentagem de nitrogênio foliar (%) de fava.

Cultivars	Humic acid (kg ha^{-1})	Phosphorus (kgP_2O_5 ha^{-1}) 80	120	160	Cultivars × Humic acid
Fava da Orto	0	2.65 f	2.84 f	4.06 c	3.18 c
	20	3.44 e	3.56 de	4.85 b	3.95 b
	40	4.57 b	4.87 b	5.37 a	4.90 a
Luz de Otono	0	2.50 f	2.83 f	3.86 cd	3.07 c
	20	3.40 e	3.52 de	4.59 b	3.84 b
	40	4.43 b	4.77 b	5.27 ab	4.89 a
Phosphorus average		3.49 c	3.71 b	4.66 a	
		Cultivars × Phosphorus			Cultivars average
Fava da Orto		3.56 bc	3.74 b	4.72 a	4.34 a
Luz de Otono		3.41 c	3.69 b	4.56 a	3.89 a
		Humic acid × Phosphorus			Humic acid average
0		2.58 g	2.84 f	3.97 d	3.11 c
20		3.42 e	3.54 e	4.72 bc	3.89 b
40		4.48 c	4.76 b	5.31 a	4.90 a

The values followed with different letters significantly differ for each other according to Duncan multiple range test at 0.05 probability level.

Table 13. Effect of cultivars, humic acid, phosphorus and interactions on leaves phosphorus percentage (%) of broad bean.
Tabela 13. Efeito de cultivares, ácido húmico, fósforo e interações na porcentagem de fósforo foliar (%) de fava.

Cultivars	Humic acid (kg ha-1)	Phosphorus (kgP_2O_5 ha-1) 80	120	160	Cultivars × Humic acid
Fava da Orto	0	0.236 j	0.256 f-i	0.260 e-h	0.251 c
	20	0.250 g-j	0.266 d-g	0.267 def	0.261 b
	40	0.276 b-e	0.283 abc	0.293 a	0.284 a
Luz de Otono	0	0.242 ij	0.252 f-i	0.258 fgh	0.250 c
	20	0.249 hij	0.263 e-h	0.266 d-g	0.259 b
	40	0.275 cde	0.280 a-d	0.291 ab	0.282 a
Phosphorus average		0.255 c	0.266 b	0.272 a	
		Cultivars × Phosphorus			Cultivars average
Fava da Orto		0.254 b	0.268 a	0.273 a	0.265 a
Luz de Otono		0.255 b	0.265 a	0.272 a	0.264 a
		Humic acid × Phosphorus			Humic acid average
0		0.239 f	0.254 e	0.259 ed	0.250 c
20		0.250 e	0.264 d	0.267 cd	0.260 b
40		0.276 bc	0.282 b	0.292 a	0.283 a

The values followed with different letters significantly differ for each other according to Duncan multiple range test at 0.05 probability level.

Table 14. Effect of cultivars, humic acid, phosphorus and interactions on pod length (cm) of broad bean.
Tabela 14. Efeito de cultivares, ácido húmico, fósforo e interações no comprimento de poda (cm) de fava.

Cultivars	Humic acid (kg ha-1)	Phosphorus (kgP_2O_5 ha-1) 80	120	160	Cultivars × Humic acid
Fava da Orto	0	16.8 g	16.6 g	20.6 cd	18.0 d
	20	19.5 def	19.4 def	21.5 bcd	20.2 c
	40	20.1 de	21.0 bcd	22.9 ab	21.3 b
Luz de Otono	0	17.7 fg	18.3 efg	22.3 abc	19.4 c
	20	20.8 bcd	21.5 bcd	22.9 ab	21.7 ab
	40	21.3 bcd	22.5 abc	23.9 a	22.6 a
Phosphorus average		19.4 b	19.9 b	22.4 a	
		Cultivars × Phosphorus			Cultivars average
Fava da Orto		18.8 d	19.0 d	21.7 b	19.8 b
Luz de Otono		20.0 cd	20.7 bc	23.1 a	21.3 a
		Humic acid × Phosphorus			Humic acid average
0		17.3 e	17.4 e	21.5 cd	18.7 c
20		20.2 d	20.4 cd	22.2 ab	20.9 b
40		20.7 cd	21.7 bc	23.4 a	21.9 a

The values followed with different letters significantly differ for each other according to Duncan multiple range test at 0.05 probability level.

3.7. Plant seed yield

Table 15 shows that the two broad bean cultivars significantly differed in plant seed yield, Fava da Orto cultivar was significantly superior to the Luz de Otono cultivar and gave plant seed yield amounted (64.2 and 61.1 g plant^{-1}), respectively for the two cultivars. The superiority of the Fava da Orto cultivar in plant seed yield is due to its superiority in yield components (data not shown), and this resulted in genetic differences, origin differences, growth habits and the response to the environmental conditions of investigated cultivation. The significant variation among broad bean cultivars in plant seed yield was noticed by many investigators Badawy et al. (2020), Mohamed et al. (2020), Abbas et al. (2022) and Abo-Hegazy; (2022).

3.8. Seeds Nitrogen and Phosphorus percentage

The presented data in Tables 16 and 17 indicates that the two broad bean cultivars did not differ significantly in seeds N and P percentages. At the same time, humic acid levels significantly affected seeds N and P percentage; with increasing humic acid levels from zero to 40 kg ha^{-1} potassium humate seeds N and P percentage significantly increased, the highest average in seeds N and P percentage were obtained from application high level of humic acid 40 kg ha^{-1} potassium humate (4.30 and 0.29 %), respectively, but the lowest average in seeds N and P percentage were obtained from control treatment (2.77 and 0.23 %), respectively. These results are due to the role of humic acid application in increasing nutrient uptake, especially N and P, from the soil to leaves (Tables 12 and 13) and then translocating these nutrients from the leaves to seeds, thereby enhancing seeds N and P content. Also, the beneficial effect of humic acid is that it contains high organic contents (Table 3), which affects soil physical and chemical properties also, it chelates nutrients, prevents them from leaching through the soil profile and makes them more available for plants (EL-KAMAR, 2020). These findings are confirmed by those obtained by Fouda (2017), El-Kamar (2020) and Awaad et al. (2020), who found that high levels of humic acid caused high seed N and P content on broad beans.

3.9. Seed protein percentage

Table 18 shows that broad bean seeds protein percentage was not significantly affected by the cultivars but was significantly affected by humic acid levels, where a high level of humic acid 40 kg ha^{-1} potassium humate significantly gave the highest average in seeds protein percentage (27.4 %) compared to control treatment which gave the lowest average in seeds protein percentage (18.2 %). These results may be because humic acid substance contains nitrogen element (Table 3), which works on increasing nitrogen availability for plants and uptake it and then translocation to seeds (Table

16), which enters into the composition of the protein through its entry in the structure of the amino acids which enter into protein composition and leads to increasing protein percentage in the seeds. The findings were in agreement with Abead et al. (2018), Al-Obaidi (2020) and Abo-Hegazy; Badawy (2022), who found that high levels of humic acid significantly caused high seed protein percentage in broad beans.

Table 15. Effect of cultivars, humic acid, phosphorus and interactions on plant seed yield (g plant^{-1}) of broad bean.
Tabela 15. Efeito de cultivares, ácido húmico, fósforo e interações na produção de sementes por planta (g planta^{-1}) de fava.

Cultivars	Humic acid (kg ha^{-1})	Phosphorus (kgP_2O_5 ha^{-1}) 80	120	160	Cultivars × Humic acid
Fava da Orto	0	38.4 j	44.5 i	54.2 fg	45.7 c
	20	56.4 b	58.5 fgh	65.4 cd	60.1 b
	40	77.5 de	78.1 b	105.0 a	86.9 a
Luz de Otono	0	32.7 j	39.6 i	47.7 f	40.0 c
	20	56.1 h	58.2 gh	67.8 c	60.7 b
	40	73.6 e	78.0 b	96.7 ab	82.8 a
Phosphorus average		55.8 c	59.5 b	72.8 a	
Cultivars × Phosphorus					Cultivars average
Fava da Orto		52.6 c	59.5 b	80.4 a	64.2 a
Luz de Otono		49.2 c	57.9 b	76.3 a	61.1 b
Humic acid × Phosphorus					Humic acid average
0		35.2 h	42.0 g	66.6 e	47.9 c
20		36.0 f	56.2 ed	75.9 c	56.0 b
40		58.3 d	77.7 b	100.8 a	78.9 a

The values followed with different letters significantly differ for each other according to Duncan multiple range test at 0.05 probability level.

Table 16. Effect of cultivars, humic acid, phosphorus and interactions on seeds nitrogen percentage (%^{1}) of broad bean.
Tabela 16. Efeito de cultivares, ácido húmico, fósforo e interações na percentage de nitrogênio na semente (%) de fava.

Cultivars	Humic acid (kg ha^{-1})	Phosphorus (kgP_2O_5 ha^{-1}) 80	120	160	Cultivars × Humic acid
Fava da Orto	0	2.51 f	2.80 ef	3.47cd	2.93 c
	20	3.13 de	3.17 de	4.23 b	3.57 b
	40	3.78 bc	4.10 b	5.36 a	4.41 a
Luz de Otono	0	2.20 fg	2.63 fg	2.97 ef	2.60 d
	20	2.97 of	3.16 de	4.20 b	3.49 b
	40	3.55 cd	4.02 b	4.98 a	4.18 a
Phosphorus average		3.03 c	3.32 b	4.20 a	
Cultivars × Phosphorus					Cultivars average
Fava da Orto		3.14 cd	3.35 c	4.35 a	3.62 a
Luz de Otono		2.91 c	3.27 c	4.06 b	3.42 a
Humic acid × Phosphorus					Humic acid average
0		2.36 f	2.77 e	3.97 d	2.77 c
20		3.06 d	3.16 d	4.20 b	3.48 b
40		3.66 c	4.06 b	5.17 a	4.30 a

The values followed with different letters significantly differ for each other according to Duncan multiple range test at 0.05 probability level.

Table 17. Effect of cultivars, humic acid, phosphorus and interactions on seeds phosphorus percentage (%^{1}) of broad bean.
Tabela 17. Efeito de cultivares, ácido húmico, fósforo e interações na percentage de fósforo na semente (%) de fava.

Cultivars	Humic acid (kg ha^{-1})	Phosphorus (kgP_2O_5 ha^{-1}) 80	120	160	Cultivars × Humic acid
Fava da Orto	0	0.20 g	0.23 f	0.25 edf	0.23 c
	20	0.24 ef	0.25 edf	0.27 cd	0.26 b
	40	0.27 cde	0.29 abc	0.32 a	0.30 a
Luz de Otono	0	0.20 g	0.23 f	0.25 edf	0.23 c
	20	0.24 f	0.24 f	0.29 bc	0.26 b
	40	0.28 bc	0.29 abc	0.31 ab	0.29 a
Phosphorus average		0.24 c	0.26 b	0.28 a	
Cultivars × Phosphorus					Cultivars average
Fava da Orto		0.24 c	0.26 ab	0.28 a	0.26 a
Luz de Otono		0.24 c	0.25 bc	0.28 a	0.25 a
Humic acid × Phosphorus					Humic acid average
0		0.20 e	0.23 d	0.25 c	0.23 c
20		0.24 cd	0.25 cd	0.28 b	0.26 b
40		0.28 b	0.29 b	0.31 a	0.29 a

The values followed with different letters significantly differ for each other according to Duncan multiple range test at 0.05 probability level.

4. DISCUSSION
4.1. Days to 50% flowering and first pod appearance

The two cultivars under high levels of humic acid 40 kg ha^{-1} potassium humate recorded significant a few days to 50% flowering (66.1 and 67.2 days) and to first pod appearance (110.8 and 111.3 days), respectively for two cultivars compared to other interactions. Also, the two cultivars under a high level of phosphorus fertilizer 160 kg P_2O_5.ha^{-1}

recorded significant a few days to 50% flowering and first pod appearance compared to their interaction with other phosphorus fertilizer levels. Interaction of all levels of humic acid with a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} caused a significant earliness in days to 50% flowering. In comparison, a high level of humic acid 40 kg ha^{-1} Potassium humate with a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} caused a significant earliness in the first pod appearance (109.5 days) compared to another interaction.

Triple interaction showed that the two cultivars under all humic acid levels and high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} was significantly earliness in days to 50% flowering, while the two cultivars under high level of humic acid 40 kg ha^{-1} potassium humate and high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} was significant earliness in first pod appearance.

Table 17. Effect of cultivars, humic acid, phosphorus and interactions on seeds protein percentage ($\%^1$) of broad bean.
Tabela 17. Efeito de cultivares, ácido húmico, fósforo e interações na percentagem de proteína na semente (%) de fava.

Cultivars	Humic acid (kg ha^{-1})	Phosphorus (kgP_2O_5 ha^{-1})			Cultivars × Humic acid
		80	120	160	
Fava da Orto	0	16.0 gh	17.5 fg	24.3 cd	19.3 c
	20	19.6 efg	20.7 def	28.3 b	22.9 b
	40	22.3 de	29.3 ab	32.0 a	28.5 a
Luz de Otono	0	13.4 h	17.2 fgh	21.4 def	17.3 c
	20	20.4 def	20.4 def	28.9 b	23.2 b
	40	21.0 def	27.4 bc	31.5 ab	26.7 a
Phosphorus average		18.8 c	22.1 b	27.9 a	
		Cultivars × Phosphorus			Cultivars average
Fava da Orto		19.3 c	22.5 b	28.5 a	23.4 a
Luz de Otono		18.3 c	21.7 b	27.2 a	22.4 a
		Humic acid × Phosphorus			Humic acid average
0		14.7 d	17.4 d	22.8 c	18.2 c
20		20.1 c	20.6 c	28.5 b	23.1 b
40		21.7 c	28.6 b	32.2 a	27.4 a

The values followed with different letters significantly differ for each other according to Duncan multiple range test at 0.05 probability level.

4.2. Leaf Area and Leaf Area Index

Humic acid application significantly increased leaf area and leaf area index compared to the control treatment. This may be due to the role of humic acid in improving membrane permeability, enzyme activities and hormonal activity, which led to plant growth stimulation through increasing cell division and elongation, then reflected positively on increasing leaf area and leaf area index on broad bean plants.

The results were in agreement with Al-Zubaidy, Al-Bawee (2018) and Abdel Nabi; Obaid (2019), who found that the application of humic acid caused a significant increase in the leaf area of broad bean plants and Jasim; Alghrebawi (2020). They found that the application of humic acid caused a significant increase in the leaf area index of broad bean plants. Application of 120 and 160 kg P_2O_5 ha^{-1} caused a significant increase in leaf area and leaf area index compared to 80 kg P_2O_5 ha^{-1}; these results show the role of phosphorus in cell division and elongation and the highest physiological growth indices were achieved under high phosphorus fertilizer levels and then photosynthesis enhanced by the vegetative growth and development of leaf area of broad bean plants. The findings are in agreement with Sarkar et al. (2017), Hailu; Ayle (2019) and Hailu et al. (2019), who mentioned that high levels of phosphorus application have a significant increase in the leaf area index on broad bean plants.

The two cultivars under humic acid application gave significantly highest value in leaf area and leaf area index compared to those under unapplied humic acid, agreed with Abdel Nabi; Obaid (2019), who found a significant interaction between broad bean hybrids and humic acid concentrations for leaf area for broad bean plants. Also, the two cultivars under 120 and 160 kg P_2O_5 ha^{-1} significantly gave the highest value in leaf area and leaf area index compared to under 80 kg P_2O_5 ha^{-1}. Interaction between humic acid levels and phosphorus fertilizer levels showed that 20 kg ha^{-1} potassium humate with 120 kg P_2O_5 ha^{-1} and 40 kg ha^{-1} potassium humate with 160 kg P_2O_5 ha^{-1} significantly gave the highest value in leaf area and leaf area index of broad bean plants compared to unused humic acid treatment with 80 kg P_2O_5 ha^{-1} which gave the lowest value in leaf area and leaf area index. Fava da Orto cultivar under the high level of humic acid 40 kg ha^{-1} potassium humate and high phosphorus fertilizer level 160 kg P_2O_5 ha^{-1} significantly gave the highest mean in leaf area and leaf area index of broad bean plants (1866.8 $cm^2.plant^{-1}$ and 1.24), respectively. In comparison, the two cultivars under unapplied humic acid and low phosphorus fertilizer level 80 kg P_2O_5 ha^{-1} gave the lowest mean in leaf area and leaf area index (1319.3 and 1324.5 cm^2 $plant^{-1}$), respectively, for leaf area of the two cultivars and (0.88) for leaf area index of two cultivars.

4.3. Leaves content of chlorophyll a, b and total

The beneficial effect of humic acid, which contains high organic matter, mineral elements and other materials (Table 3), affects soil physical and chemical properties and chelates nutrients, preventing them from leaching and making them more available for plants, especially Manganese and Nitrogen which are required for the biosynthesis of chlorophyll. The findings are in agreement with Al-Zubaidy; Al-Bawee (2018), El-Kamar (2020) and Mahdi et al. (2021). They pointed out that a high level of humic acid significantly caused an increase in broad bean leaves and the content of photosynthetic pigments. Regarding the effect of phosphorus fertilizer, the results indicated that chlorophyll a, b and total content significantly increased with an increasing phosphorus fertilizer level from 80 to 160 kg P_2O_5 ha^{-1}. The highest values were recorded (4.68, 2.19 and 6.87 mg g^{-1} F.W.) for leaves chlorophyll content a, b and total was realized for the 160 kg P_2O_5 ha^{-1}. The lowest values were recorded (3.22, 1.57 and

4.79 mg g^{-1} F.W.) for leaves chlorophyll content a, b and total was realized for the 80 kg P_2O_5 ha^{-1}. These results may be due to the role of phosphorus in stimulating a large number of enzymes which is responsible for chlorophyll building. The results are in agreement with Azzam (2019), Sakara; Baddour (2020) and Esmail (2021), who reported that high levels of phosphorus fertilizer significantly caused high leaves chlorophyll content in broad bean plants.

Regarding the effect of the interaction, the results revealed that two cultivars under a high level of humic acid 40 kg ha^{-1} potassium humate significantly gave the highest value in leaves content of chlorophyll a and total (5.08 and 5.21 mg g^{-1} F.W.), respectively for chlorophyll content and (7.68 and 7.94 mg g^{-1} F.W.), respectively for total chlorophyll content, while Luz de Otono cultivar under the high level of humic acid 40 kg ha^{-1} potassium humate significantly gave the highest value in leaves content of chlorophyll b (2.72 mg g^{-1} F.W.) compared to two cultivars performance with untreated humic acid treatment which gave the lowest value in leaves content of chlorophyll a, b and total (2.86 and 2.89 mg g^{-1} F.W.), respectively for chlorophyll a content, (1.13 and 1.23 mg g^{-1} F.W.), respectively for chlorophyll b content and (3.99 and 4.12 mg g^{-1} F.W.), respectively for total chlorophyll content.

Also, the two cultivars under the high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave the highest value in leaves content of chlorophyll a and total (4.64 and 4.73 mg g^{-1} F.W.), respectively for chlorophyll a content and (6.78 and 6.99 mg g^{-1} F.W.), respectively for total chlorophyll content, while Luz de Otono cultivar under a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave the highest value in leaves content of chlorophyll b (2.26 mg g^{-1} F.W.) compared to the two cultivars performance under low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} which gave a lowest value in leaves content of chlorophyll a, b and total (3.18 and 3.27 mg g^{-1} F.W.), respectively for chlorophyll a content, (1.52 and 1.62 mg g^{-1} F.W.), respectively for chlorophyll b content and (4.70 and 4.89 mg g^{-1} F.W.), respectively for total chlorophyll content.

A high level of humic acid 40 kg ha^{-1} potassium humate with a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly recorded the highest value in leaves content of chlorophyll a, b and total (6.40, 3.05 and 9.45 mg g^{-1} F.W.), respectively compared to zero level of potassium humate with low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} which recorded the lowest value in leaves content of chlorophyll a, b and total (2.55, 0.92 and 3.47 mg g^{-1} F.W.), respectively.

The two cultivars under a high level of humic acid 40 kg ha^{-1} potassium humate and high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly recorded the highest mean in leaves content of chlorophyll a, b and total (6.37 and 6.42 mg g^{-1} F.W.), respectively for chlorophyll content, (2.97 and 3.12 mg g^{-1} F.W.), respectively for chlorophyll b content and (9.34 and 9.54 mg g^{-1} F.W.), respectively for total chlorophyll content compared to the two cultivars under zero humic acid level and low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} which recorded the lowest mean in leaves content of chlorophyll a (2.51 and 2.56 mg g^{-1} F.W.), respectively and Fava da Orto cultivar under zero humic acid level and low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} which recorded the lowest mean in leaves content of chlorophyll b and total (0.87 and 3.38 mg g^{-1} F.W.), respectively.

4.4. Plant dry matter yield

Concerning phosphorus fertilizer, the results revealed that plant dry matter yield was increased significantly with an increasing phosphorus fertilizer level; a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave the highest average in plant dry matter yield (83.1 g $plant^{-1}$) compared to low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} which gave the lowest average in plant dry matter yield (78.8 g $plant^{-1}$). These results confirmed the role of phosphorus in increasing the transfer and assembly process for dry matter and delaying the period of leaf senescence, which leads to an increase in dry matter accumulation in plants. The beneficial effect of phosphorus on plant dry matter yield on broad beans was also observed by Azzam (2019), Sakara; Baddour (2020) and Esmail (2021).

The two cultivars under high levels of humic acid 40 kg ha^{-1} potassium humate recorded the highest value in plant dry matter yield (86.7 and 86.8 g $plant^{-1}$), respectively. The two cultivars with untreated humic acid treatment recorded the lowest value in plant dry matter yield (76.8 and 76.0 g $plant^{-1}$), respectively. The two cultivars under a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly recorded the highest value in plant dry matter yield (83.2 and 82.9 g $plant^{-1}$), respectively. In contrast, it recorded the lowest value in plant dry matter yield under a low level of phosphorus fertilizer 80 kg P2O5 ha-1 (79.5 and 78.6 g $plant^{-1}$), respectively.

Regarding the effect of interaction between humic acid and phosphorus fertilizer, the results showed that a high level of humic acid 40 kg ha^{-1} potassium humate with a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly recorded the highest value in plant dry matter yield (90.1 g $plant^{-1}$) compared to untreated humic acid treatment with 80 and 120 kg P_2O_5 ha^{-1} which recorded the lowest value in plant dry matter yield (74.7 and 75.4 g $plant^{-1}$), respectively. The results agreed with Fouda (2017), who found that the foliar application of humic acid under different phosphorus fertilizer levels significantly increased plant dry weight on broad beans.

The triple interaction among three studied factors showed that the Fava da Orto cultivar under a high level of humic acid 40 kg ha^{-1} potassium humate and high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly recorded the highest mean in plant dry matter yield (90.6 g $plant^{-1}$), while the two cultivars under untreated humic acid treatment and low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} recorded the lowest mean in plant dry matter yield (75.4 and 74.1 g $plant^{-1}$), respectively.

4.5. Leaves nitrogen and phosphorus percentage

Broad bean leaves N and P percentages significantly increased with an increasing phosphorus fertilizer level from 80 to 160 kg P_2O_5 ha^{-1}; high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave the highest average in leaves N and P percentages (4.66 and 0.272 %), respectively compared to low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} which gave a lowest average in leaves N and P percentage (3.49 and 0.255 %), respectively. These findings may be due to the role of phosphorus in improving root system growth and developing a good root system of the plant, which contributes to more uptake of N and P and their transfer to the leaves because of its increase in availability around the roots, and a beneficial effect of phosphorus on stimulating the development of root hairs which absorb more nutrients from the soil solution (FOUDA, 2017). The results were in harmony with Sakara; Baddour (2020), who found that the phosphorus content of broad beans increased with increased phosphorus application levels.

The two cultivars under high levels of humic acid 40 kg ha^{-1} potassium humate significantly recorded the highest value in leaves N and P percentages (4.90 and 4.89 %), respectively for N and (0.284 and 0.282 %), respectively for P compared to the two cultivars with untreated humic acid treatment which recorded the lowest value in leaves N and P percentage (3.18 and 3.07 %), respectively for N and (0.251 and 0.250 %), respectively for P.

The two cultivars under the high level of phosphorus fertilizer application 160 kg P_2O_5 ha^{-1} significantly recorded the highest value in leaves N percentage (4.72 and 4.56 %), respectively compared to Luz de Otono cultivar under low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} which recorded the lowest value in leaves N percentage (3.41 %), while The two cultivars under 120 and 160 kg P_2O_5 ha^{-1} significantly recorded a highest value in leaves P percentage (0.268 and 0.265 %), respectively under 120 P_2O_5 ha^{-1} and (0.273 and 0.272 %), respectively under 160 P_2O_5 ha^{-1} compared to the two cultivars under low level of phosphorus fertilizer application 80 kg P_2O_5 ha^{-1} which recorded the lowest value in leaves P percentage (0.254 and 0.255 %), respectively.

A high level of humic acid 40 kg ha^{-1} potassium humate with a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly recorded the highest value in leaves N and P percentage (5.31 and 0.292 %), respectively. In comparison, untreated humic acid treatment with a low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} recorded the lowest value in leaves N and P percentage (2.58 and 0.239 %), respectively. The highest increase in leaves N and P percentages may be because humic acid helped in solubilizing phosphorus from insoluble to soluble, resulting in its increasing uptake and then translocation to leaves also, humic acid helped in increasing nitrogen availability by its containing nitrogen and increasing roots nodules number and nitrogen fixation.

The Fava da Orto cultivar under high level of humic acid 40 kg ha^{-1} Potassium humate and high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly recorded the highest mean in leaves N and P percentage (5.37 and 0.293 %), respectively, while the two cultivars under untreated humic acid treatment and low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} recorded a lowest mean in leaves N percentage (2.65 and 2.50 %), respectively. In contrast, the Fava da Orto cultivar, under untreated humic acid treatment and low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} recorded the lowest mean in leaves P percentage (0.236 %).

4.6. Pod length (cm)

Regarding interactions, the Luz de Otono cultivar under the high level of humic acid 40 kg ha^{-1} potassium humate significantly gave a longer pod (22.6 cm). In comparison, the Fava da Orto cultivar with unused humic acid treatment gave a shorter pod (18.0 cm). Also, the Luz de Otono cultivar under the high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave a longer pod (23.1 cm). Under 80 and 120 kg P2O5 ha^{-1}, the Fava da Orto cultivar gave a shorter pod (18.8 and 19.0 cm), respectively. It's found that the interaction between broad bean cultivars and phosphorus fertilizer levels significantly influences broad bean pod length. A high level of humic acid 40 kg ha^{-1} potassium humate with a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave a longer pod (23.4 cm). In contrast, unused humic acid treatment with 80 and 120 kg P_2O_5 ha^{-1} gave a shorter pod (17.3 and 17.4 cm), respectively. Concerning triple interaction, the broad bean cultivar Luz de Otono under the high level of humic acid 40 kg ha^{-1} potassium humate and a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave a longer pod (23.9 cm), whereas Fava da Orto cultivar with an unused humic acid treatment and with 80 and 120 kg P_2O_5 ha^{-1} gave a shorter pod (16.8 and 16.6 cm), respectively.

4.7. Plant seed yield

Plant seed yield on broad bean significantly increased with an increase of humic acid levels from zero to 20 kg ha^{-1} potassium humate and then to 40 kg ha^{-1} potassium humate; a high level of humic acid 40 kg ha^{-1} potassium humate significantly gave the highest average in plant seed yield (78.9 g $plant^{-1}$) compared to control treatment which gave the lowest average in plant seed yield (47.9 g $plant^{-1}$). This may be due to the role of humic acid, which is rich in mineral and organic substances (Table 3) and is essential to plant growth and increase seed yield components. The superiority of a high level of humic acid 40 kg ha^{-1} potassium humate due to its superiority in leaf area, leaf area index, leaves chlorophyll content, plant dry matter yield leaves N and P content and pod length, all of which contribute to its superiority in plant seed yield. The significant positive effect of humic acid in increasing plant seed yield on broad beans mentioned by El-KholY et al. (2019), Al-Obaidi (2020), Mahdi et al. (2021) and Abo-Hegazy; Badawy (2022).

Also, plant seed yield on broad bean significantly increased with an increase of phosphorus fertilizer levels from 80 to 120 then to 160 kg P_2O_5 ha^{-1}; high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave a highest average in plant seed yield (72.8 g $plant^{-1}$) and low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} gave a lowest average in plant seed yield (55.8 g $plant^{-1}$). The findings stated the vital role of the high level of phosphorus fertilizer in improving broad bean productivity through increasing leaf area, leaf area index, leaves chlorophyll content, plant dry matter yield, leaves N and P content and pod length, which reflected on increasing plant seed yield. Moreover, the increase in plant seed yield as a result of a high level of phosphorus fertilizer application can be easily ascribed to the low soil content of available P (Table 1); phosphorus is considered one of the major elements for plant nutrition and its positive impact on plant seed yield had been reported by El-Kholy et al. (2019).

The two cultivars under high levels of humic acid 40 kg ha^{-1} potassium humate recorded the highest value in plant seed yield (86.9 and 82.8 g $plant^{-1}$), respectively. In comparison, the two cultivars with untreated humic acid treatment recorded the lowest value in plant seed yield (45.7 and 40.0 g $plant^{-1}$), respectively. The results confirm the findings of Abo-Hegazy; Badawy (2022), who indicated a significant interaction between broad bean cultivars and humic acid levels.

The two cultivars under the high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly recorded the highest value in plant seed yield (80.4 and 76.3 g plant^{-1}), respectively. In comparison, the two cultivars under the low level of phosphorus fertilizer 80 kg P_2O_5.ha^{-1} recorded the lowest value in plant seed yield (52.6 and 49.2 g plant^{-1}), respectively. Interaction between a high level of humic acid 40 kg ha^{-1} potassium humate with a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly recorded the highest value in plant seed yield (100.8 g plant^{-1}). In contrast, unused humic acid treatment with a low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} recorded the lowest value in plant seed yield (35.2 g plant^{-1}). The results are under those El-Kholy et al. (2019) reported, indicating a significant interaction between humic acid levels and phosphorus fertilizer levels on broad bean plant seed yield.

The Fava da Orto cultivar under high level of humic acid 40 kg ha^{-1} potassium humate with high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave a highest mean in plant seed yield (105.0 g plant^{-1}), whereas the two cultivars under unused humic acid treatment and low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} gave a lowest mean in plant seed yield (38.4 and 32.7 g plant^{-1}), respectively. It is clear from these results that there is a high response to high levels of humic acid and phosphorus fertilizer by broad bean plant seed yield and this is due to low soil content of organic and mineral substances (Table 1) for an experiment field soil.

4.8. Seeds Nitrogen and Phosphorus percentage

Also, broad bean seeds N and P percentages significantly increased with increasing phosphorus fertilizer levels from 80 to 160 kg P_2O_5 ha^{-1}. Application of a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave the highest average in seeds N and P percentage (4.20 and 0.28 %), respectively, compared to low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} which gave the lowest average in seeds N and P percentage (3.03 and 0.24 %), respectively. These results may be due to the role of phosphorus in root development and increasing hair root, which leads to increasing mineral elements uptake from soil in addition to available phosphorus was increased with a high phosphorus fertilizer application level, which lead to the increasing number of root nodules and increasing atmosphere nitrogen fixing and then its uptake and transition to plant shoot and to the seeds in the end. The findings are confirmed with those reported by Fouda (2017) and Awaad et al. (2020), who mentioned that applying phosphorus fertilizer to broad bean plants increased seed content of N and P %.

Regarding interactions among studied factors, the two cultivars under high levels of humic acid 40 kg ha^{-1} potassium humate significantly recorded the highest value in seeds N and P percentage (4.41 and 4.18 %), respectively for N and (0.30 and 0.29 %), respectively for P. In contrast, the Luz de Otono cultivar with untreated humic acid treatment recorded the lowest value in seeds N percentage (2.60 %). In contrast, the two cultivars with untreated humic acid treatment recorded the lowest value in leaves P percentage (0.23 %) for two cultivars.

Concerning the interaction between cultivars and phosphorus fertilizer levels, the data showed that the Fava da Orto cultivar under the high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave the highest value in seeds N percentage (4.35 %) compared to the Luz de Otono cultivar which gave under low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} the lowest value in seeds N percentage (2.91 %). In contrast, the two cultivars under the high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave the highest value in seeds P percentage (0.28 %) for two cultivars, compared to two cultivars under low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} which gave the lowest value in seeds P percentage (0.24 %) for two cultivars.

A high level of humic acid 40 kg ha^{-1} potassium humate and a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly recorded the highest value in seeds N and P percentages (5.17 and 0.31 %), respectively. In comparison, zero humic acid level with a low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} recorded the lowest value in seeds N and P percentage (2.36 and 0.20 %), respectively. These results agree with Fouda (2017) and Awaad et al. (2020), who indicated that applying a high level of phosphorus fertilizer combined with a high level of humic acid caused significantly the highest percentage of broad bean seeds N and P.

For the triple interaction, the data showed that the two cultivars under high level of humic acid 40 kg ha^{-1} Potassium humate and a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave a highest mean in seeds N percentage (5.36 and 4.98 %), respectively, while the Fava da Orto cultivar under untreated humic acid treatment and low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} gave a lowest mean in seeds N percentage (2.51 %). The Fava da Orto cultivar under a high level of humic acid 40 kg ha^{-1} potassium humate and a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave the highest mean in seeds P percentage (0.32 %). In comparison, the two cultivars under untreated humic acid treatment and low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} gave the lowest mean in leaves P percentage (0.20 %) for the two cultivars.

4.9. Seed protein percentage

With an increase in phosphorus fertilizer levels, broad bean seeds protein percentage increased; a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly recorded the highest average in seeds protein percentage (27.9 %), while a low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} recorded the lowest average in seeds protein percentage (18.8 %). These findings may be due to the vital role of phosphorus in increasing root nodules number, and this leads to increasing atmosphere nitrogen fixing and absorption by roots and translocation into seeds and its entry in protein composition and then increase seeds protein percentage; we noticed from this study the role of high level of phosphorus in increasing leaves and seeds nitrogen content (Table 12 and 16) which has a big role in increasing seeds protein percentage. The role of high phosphorus fertilizer levels in increasing broad bean seed protein percentage was also observed by Sakara; Baddour (2020) and Esmail (2021).

The two cultivars under high levels of humic acid 40 kg ha^{-1} potassium humate significantly recorded the highest value in seed protein percentage (28.5 and 26.7 %), respectively. In comparison, the two cultivars with untreated humic acid treatment recorded the lowest value in seed protein percentage (19.3 and 17.3 %), respectively. The significant interaction of broad bean cultivars with humic acid application was recorded by Abead et al. (2018) and Abo-Hegazy; Badawy (2022) reported that broad bean cultivars under high level of humic acid recorded a high value in seeds protein percentage.

The two cultivars under a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly recorded the highest value in seeds protein percentage (28.5 and 27.2 %), respectively. In comparison, the two cultivars under a low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} recorded the lowest value in seeds protein percentage (19.3 and 18.3 %), respectively.

Regarding the interaction between humic acid and phosphorus fertilizer level, the data confirmed that a high level of humic acid 40 k ha^{-1} potassium humate with a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly recorded the highest value in seeds protein percentage (32.2 %). In contrast, zero humic acid levels with phosphorus fertilizer levels 80 and 120 kg P_2O_5 ha^{-1} recorded the lowest value in seeds protein percentage (14.7 and 17.4 %), respectively.

Concerning the triple interaction among studied factors, the presented data in Table 18 showed that the Fava da Orto cultivar under a high level of humic acid 40 kg ha^{-1} potassium humate and a high level of phosphorus fertilizer 160 kg P_2O_5 ha^{-1} significantly gave the highest mean in seeds protein percentage (32.0 %). In contrast, the Luz de Otono cultivar under zero humic acid level and low level of phosphorus fertilizer 80 kg P_2O_5 ha^{-1} gave the lowest mean in seeds protein percentage (13.4 %).

5. CONCLUSIONS

It was concluded from this investigation that the two tested broad bean cultivars did not differ with each other as well as in their response to humic acid and phosphorus fertilizer levels for most of the studied traits. The two cultivars showed a high response to high levels of humic acid and phosphorus fertilizer, Fava da Orto cultivar was more adapted and profitable for farmers than the Luz de Otono cultivar because the Fava da Orto cultivar gave the highest plant seed yield due to its adaptation to Kirkuk environment. The results of this investigation highlight the role of humic acid and phosphorus fertilizer in improving broad bean cultivars growth and seed yield which increased significantly under high levels of humic acid and phosphorus fertilizer because of poor soils content in organic matter and mineral elements (Table 1) especially in macronutrients N, P and K elements. For producing the highest vegetative growth and seed yield of broad bean plants and increasing the leaves and seeds chemical contents and seeds protein percentage it could be suggested to sow Fava da Orto cultivar with fertilized 40 kg ha^{-1} Potassium humate and 160 kg $P_2O_5.ha^{-1}$ under the environmental conditions of Kirkuk Governorate, Iraq.

6. REFERENCES

A.O.A.C. **Official methods of analysis. Association of Official Analytical Chemists**. 13 Ed. Washington, D.C.: AOAC ,1980. 3750p.

ABBAS, M. S.; BADAWY, R. A.; ABDEL-LATTIF, H. M.; EL-SHABRAWI, H. M. Synergistic effect of organic amendments and biostimulants on faba bean grown under sandy soil conditions. **Scientia Agricola**, v. 79, e20200300, 2021. https://doi.org/10.1590/1678-992X-2020-0300

ABD ALQADER, O. A.; AL-JOBOURI, S. M.; ESHOAA, L. M. H. Effect of nitrogenous and urea nano-hydroxyapatite fertilizer on growth and yield of two cultivars of broad bean (*Vicia Faba* L.). **Euphrates Journal of Agriculture Science**, v. 12, n. 2, p. 202-227, 2020.

ABEAD, H. M.; HAMMADI, H. J.; SALAMA, M. A. Effect of humic acid foliar in the growth, yield and quality of several genotypes four of vicia Faba L. **Al-Anbar Journal of Agricultural Sciences**, v. 16, n. 2, p. 52-61, 2018.

ABED, I. M.; JABBAR, M. K.; MNSOUR, R. J. Study of Faba bean stimulation by spraying different concentrations of Ethel Methane Sulphate on shoot apexes. **Ecology, Environment and Conservation**, v. 27, n. 2, p. 628-631, 2021.

ABO-HEGAZY, S. R.; BADAWY, R. A. 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 Journal of Plant Scienc**e, v. 21, p. 39-48, 2021. https://doi.org/10.3923/ajps.2022.39.48

AL-OBAIDI, S. I. Y. **Effect of applying methods of Algren twin and humic acid on traits of growth, yield and its components of bean crop (*Vicia faba* L.)**. M.Sc. Thesis, College of Agriculture and Forestry, University of Mosul, Iraq, 2020.

ALRAWI, M. M.; AL-MHARIB, M. Z.; ALWAN, A. M.; NASER, A. R. Response seeds production of broad bean to foliar spray with magnesium and boron**. Iraqi Journal of Agricultural Sciences**, v. 54, n. 1, p. 229-234, 2023. https://doi.org/10.36103/ijas.v54i1.1695

ALSAWAF, A.; IBRAHEEM, F. F. Effect of cultivars, apical pinching and copper nano-fertilizer on green pods characteristics of broad bean (Vicia faba L.) was Fadhiliya area. **Eastern Journal of Agricultural and Biological Sciences**, v. 3, n. 1, p. 69-76, 2023.

AWAAD, M. S.; SHAZLY, M. E.; DESHESH, T. H. Effect of potassium humate and phosphorus fertilization on faba bean plants of yield and its content of nutrients. **Menoufia Journal of Soil Science**, v. 5, n. 7, p. 161-71, 2020. https://dx.doi.org/10.21608/mjss.2020.171536

AZIZA, A.; ABDEL-AZIZ, M.; MOSTAFA, N. F.; TALAAT, H. S.; HODA, F. Z. Effects of Spacing, Humic Acid and Boron on Growth, Seed Production and Quality of Broad Bean (Vicia faba var major L). **Alexandria Journal of Agricultural Sciences**, v. 64, n. 3, p. 207-217, 2019.

AZZAM, M. R. Effect of sheep dung and phosphor fertilizer on growth and yield of *Vicia faba* L. **Syrian Journal of Agricultural Research**, v. 6, n. 3, p. 263-271, 2019.

BADAWY, R. A.; ABBAS, M. S.; ABDEL-LATTIF, H. M.; ALY, A. M. Productivity of some faba bean cultivars and its pan bread characteristics as influenced by organic fertilizers under newly reclaimed salinity sandy soil. **Journal of Plant Production**, v. 11, n. 12, p. 1251-1260, 2020. https://dx.doi.org/10.21608/jpp.2020.149795

EL-KAMAR, F. A. Effect of humic acid and yeast waste application on fababean (*Vicia Faba*) yield, yield components and some soil properties of salt affected soil. **Journal of Soil Sciences and Agricultural Engineering**, v. 11, n. 9, p. 483-488, 2020. https://doi.org/10.21608/JSSAE.2020.118340

EL-KHOLY, A. S.; ALY, R. M.; EL-BANA, A. Y.; YASIN M. A. Yield of faba bean (*Vicia faba*, l.) as influenced by planting density, humic acid rate and phospohorus fertilization level under drip irrigation system in sandy soils. **Zagazig Journal of Agricultural Research**, v. 46,

n. 6, p. 1785-1795, 2019. https://doi.org/10.21608/zjar.2019.51869

EMAM, S. M.; SEMIDA, W. M. Foliar-applied Amcoton® and potassium thiosulphate enhances the growth and productivity of three faba beans varieties by improving photosynthetic efficiency. **Archives of Agriculture and Environmental Sciences**, v. 5, n. 2, p. 89-96, 2020. https://doi.org/10.26832/24566632.2020.050202

ESMAIL, E. E. The Response of the broad bean crop (*Vicia faba* L.) to phosphate and potassium fertilization and their effect on the growth and yield characteristics. **Tikrit Journal of Pure Science**, v. 26, n. 1, p. 40-46, 2021. https://doi.org/10.25130/tjps.v26i1.96

ESTEFAN, G.; SOMMER, R.; RYAN, J. Methods of soil, plant, and water analysis. **A manual for the West Asia and North Africa region**, v. 3, p. 65-119, 2013. https://www.aktion-wuestenwald.de/app/download/5794918017/Soil,+Plant+and+Water+Analysis+-+ICARDA+2013.pdf

FARID, I. M.; EL-GHOZOLI, M. A.; ABBAS, M. H. H.; EL-ATRONY, D. S.; ABBAS, H. H.; ELSADEK, M.; A. SAAD, A. S.; EL NAHHAS, N.; MOHAMED, I. Organic materials and their chemically extracted humic and fulvic acids as potential soil amendments for Faba Bean cultivation in soils with varying CaCO3 contents. **Horticulturae**, v. 7, n. 8, e205, 2021. https://doi.org/10.3390/horticulturae7080205

FOUDA, K. F. Effect of phosphorus level and some growth regulators on productivity of faba bean (*Vicia faba* L.). **Egypt Journal of Soil Sciences**, v. 57, n. 1, p. 73-87, 2017. https://dx.doi.org/10.21608/ejss.2017.3593

HAILU, T.; AYLE, S. Influence of plant spacing and phosphorus rates on yield related traits and yield of faba bean (*Vicia faba* L.) in Duna district Hadiya zone, South Ethiopia. **Journal of Agriculture and Crops**, v. 5, n. 10, p. 191-201, 2019. https://dx.doi.org/10.32861/jac.510.191.201

HAMOOD, A. S.; JUMAAH, N. A. Effect of foliar nutrition of humic acid and chelated iron in growth and yield of broad beans (*Vicia faba* L.). **Diyala Agricultural Sciences Journal**, v. 10, n. 2, p. 137-44, 2018.

JASIM, A. H.; AL-AMIRI, K. A. Effect of soil mulching, soil phosphorus fertilizer and humic acid on broad bean yield. **Plant Archives**, v. 20, n. 2, p. 6481-644, 2020.

JASIM, A. H.; ALGHREBAWI, K. A. Effect of soil mulch, phosphorus levels and humic acid spray on the growth and green pods yield of broad bean. **DYSONA - Applied Science**, v. 1, n. 3, p. 88-95, 2020. https://doi.org/10.30493/das.2020.241168

MACKINNEY, G. Absorption of light by chlorophyll solutions. **Journal of Biological Chemistry**, v. 140, n. 2, p. 315-22, 1941. https://doi.org/10.1016/S0021-9258(18)51320-X

MAHDI, A. H.; BADAWY, S. A.; ABDEL LATEF, A. A.; EL HOSARY, A. A.; ABD EL RAZEK, U. A.; TAHA, R. S. Integrated effects of potassium humate and planting density on growth, physiological traits and yield of Vicia faba L. grown in newly reclaimed soil. **Agronomy**, v. 11, n. 3, e461, 2021. https://doi.org/10.3390/agronomy11030461

MOHAMED, M. H.; BADR, E. A.; SADAK, M. S.; KHEDR, H. H. 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. **Bulletin of the National Research Centre**, v. 44, p. 1-8, 2020. https://doi.org/10.1186/s42269-020-00359-z

NABI, H. A.; OBAID, A. K. Effect of humic acid on some growth characteristics and green yield of two hybrids of broad bean (*Vicia faba* L.). **Basrah Journal of Agricultural Sciences**, v. 32, p. 256-261, 2019. https://doi.org/10.37077/25200860.2019.273

SAKARA, H. M.; BADDOUR, A. G. Response of Faba Bean to Phosphorus Fertilization and Zinc Application under Inoculation with Psb. **Journal of Soil Sciences and Agricultural Engineering**, v. 11, n. 9, p. 513-519, 2020. https://dx.doi.org/10.21608/jssae.2020.118358

SALEH, A. A. M.; SALEH, S. M. Effect of stimulating by gibberellic acid and different spraying periods of Basagran herbicide on the growth yield of their yield of three genotypes of leguminous crop *Vicia faba* L. INTERNATIONAL SCIENTIFIC CONFERENCE FOR COLLAGE OF AGRICULTURE, 8-2, **Proceedings...** University of Tikrit, Iraq. 1-2 Jun, 2020 (part 1).

SAS INSTITUTE. **The SAS system for Windows v. 9.00 SAS Institute Inc**., Cary, NC, USA, 2002.

WATSON, D. J. The dependence of net assimilation rate on leaf-area index. **Annals of Botany**, v. 22, p. 37-54, 1958. https://doi.org/10.1093/oxfordjournals.aob.a083596

Authors' contribution: The three authors participated in all stages of the article, read and agreed to the published version of the manuscript.

Financing: *Not applicable.*

Review by institutional committee: *Not applicable.*

Ethics Committee: *Not applicable.*

Data availability: Study data can be obtained by request to the corresponding author or the second author, via e-mail. It is not available on the website as the research project is still under development.

Conflicts of Interest: The authors declare no conflict of interest. Supporting entities had no role in the study's design; in the collection, analysis, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.