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Response of some faba bean varieties (*Vicia faba* L.) to different concentrations of organic fertilizer (fulvic acid)

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ABSTRACT

A field experiment was conducted during 2023-2024 agricultural season in fields of Department of Plant Production Techniques/ Agricultural Technical College/ Northern Technical University. planting date was 7/11/2023, experiment aimed to compare faba bean varieties in terms of their response to different concentrations of fulvic acid fertilization. using a randomized complete block design (R.C.B.D) with 24 experimental units. experiment included two factors: first factor was varieties of faba bean crop, which included a Spanish variety and an Italian variety. second factor included four levels of fulvic acid fertilizer (zero, half recommended amount, 100 g. dunum⁻¹, recommended amount, 200 g. dunum⁻¹, double the amount, 400 g. dunum⁻¹), where the plants were sprayed at 3-5 true leaf stage with biofertilizer. results showed that Italian variety was superior in pod length, which reached 20.16 cm, and seed yield, which reached 165.25 g. m⁻² and percentage of protein in seeds reached 19.48%. It also exceeded recommended fertilizer quantity of 400 g. dunum⁻¹ in all studied traits, compared to treatments used in experiment, which amounted to 79.77 cm for plant height, 4.11 branches per plant, 4.72 pods per plant, 21.39 cm pod length, and 531.39 g. m⁻² for biological yield, 184.21 g. m⁻² seed yield and percentage of protein 20.71%.



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Introduction:

faba bean producer, *Vicia faba* L., is one of the diverse projects of the legume Fabaceae in many parts of the world, including Iraq. It occupies third place after both beans and peas. It represents an important element in worldwide food production system and one of the Field crops [1, 2, 3,4]. It is often attributed to its multiple uses, whether as green pods, green grains, or main agricultural materials for the wonderful materials that profit (40-46%) producing products that range between (28-38%). Moreover, it can fix nitrogen more. of other leguminous species in soil, and this reduces dependence on nitrogen fertilizers in agriculture. [5,6, 7 , 8 , 9] Global production of bean crop reached 5.669.185 tons. While total cultivated area globally amounted to 2.671.497 hectares, the cultivated area in Iraq of bean crop amounted to about [24.703] dunums, and total production amounted to [45.059] tons, and its average production amounted to (1.824.0) kg. dunum⁻¹ of seeds. production of the bean crop was estimated at (45.1) thousand tons for the year 2020, an increase of (16.8%) over production of the year 2019, which was estimated at (38.6) thousand tons [10]. Various animal and plant organic fertilizers are among most important natural sources affecting soil properties and fertility, up to percentages of organic matter in soil [11, 7]. Biofertilizers are important in increasing agricultural production, improving its quality, and reducing environmental pollution by reducing chemical fertilizers [12, 13]. Fulvic acid is beneficial because it is an organic matter with a complicated structure that results from decomposition of animal and plant materials. It plays a major function in plant nutrition and also has a favorable effect on increasing enzyme activity, improvement cell division, and cell elongation in plant tissues. Recent studies tend to raise efficiency of agricultural production by using high-yielding varieties through the use of varieties characterized by their high quality. of production and under influence of using modern methods in serving crop, which will be reflected in future in improving and increasing production in quantity and quality. One of materials used in this field is adding vital organic materials that encourage growth, whether by adding them to soil or by foliar spraying [14, 12,13] pointed out in a study of effect of organic fertilizers of plant origin on different varieties of bean crop. results indicated that Spanish variety plants were significantly superior with highest values for number of branches per plant, while Dutch variety gave highest values in weight per 100 seeds. interaction between varieties and

fertilizer treatments had a significant effect on yield traits. [2,10,16,15] Fulvic acid It is distinguished by its high ability to retain most of ions present in soil solution, this also affects the degree of interaction in root environment, this leads to an increase in readiness of many elements by chelating them and preserving them in a way that is accessible to plant. This is because fulvic acids contain active groups such as carboxyl, phenol, alcohol, quinone, carbonyl, and amine [17,25]. Many studies have also indicated that fulvic acid are prime components of 64-70% of organic matter [2,18,19]. mentioned that fulvic acid is a wide family of organic compounds that have benefits for plant growth through roles it plays in soil, as it improves phosphorus absorption by chelating calcium and preventing formation of calcium phosphate. It has been noted that fulvic acids stimulate gibberellins, increase seed germination and root respiration, and contribute to increasing permeability of plant membranes, stimulating the absorption of elements, and increasing photosynthesis. [20]. [21] showed that adding fulvic acid to certain bean cultivars led to a significant increase in the number of pods and number of seeds per pod. [22] found that addition led to a significant increase in number of seeds. Pod⁻¹, reaching 4.33 seeds. pod⁻¹. A study showed that spraying One-time faba bean with fulvic acid at a concentration of 2-3 g.L⁻¹ lead to a significant increment in pod length by 15-25% compared to untreated plants. This was the result of improving absorption of elements and stimulating longitudinal tissue growth [23]. response of faba bean varieties to fertilization with fulvic acid varies based on the genetic traits of each variety. In a study conducted on two cultivars (Aquadulce and Giza 843), researchers observed that Giza 843 showed a greater response due to increased protein content in seeds compared to another cultivar [24]. study aimed to determine response of the best variety used in experiment to best concentration of organic fertilizer, fulvic acid.

Materials and methods:

experiment was carried out in Agricultural Technical College / Mosul fields during 2023- 2024 season. This study used two varieties of faba bean and four levels of 80% fulvic acid biofertilizer. To compare varieties and fertilizer levels and interaction between them, the land was plowed and divided into equal experimental units, where area of experimental unit was 1 m². Irrigation was based on rain supplementary irrigation when needed. planting process was carried out in lines, where distance between line and another was 25 cm, and

between plant and another was 25 cm. experiment applied using a completely randomized block design (R.C.B.D), two factors. first factor is varieties, which include two varieties of bean crop (a Spanish variety and an Italian variety). second factor: Biofertilizer 80% fulvic acid, and it includes four levels (zero - 100 gm⁻¹ dunam - half recommended amount - 200 gm⁻¹ dunam - recommended amount- 400 gm⁻¹ dunam - twice recommended amount). experiment included 24 experimental units. area of experimental unit 1 m², in which fertilizer levels were randomly distributed according to each variety. data obtained for the studied traits were analyzed using the computer programs SAS (Statistical Analysis System) and Microsoft Office Excel to implement all statistical procedures. Comparisons between means were performed by Duncan's multiple-range method. Traits studied: plant height. Five plants were measured randomly from each experimental unit from the soil surface to end of main branch of plant. Number of branches. Plant⁻¹. Five randomly selected plants were taken for each experimental unit, and then average number of branches for each plant was calculated. Number of pods. Plant⁻¹. It was calculated from the average of five plants randomly selected from the middle lines of each experimental unit. Pod length (cm). Pod length was calculated as average of five pods taken randomly from midline plants. Trait of biological yield. gm⁻². plants of experimental unit, with an area of 1 m², were weighed at harvest stage, and plants were taken in all their parts. They were placed in perforated paper bags and placed under sunlight to dry, then samples were weighed with an electronic balance. Seed yield .gm⁻². plants of experimental unit were harvested, and then seeds were isolated from them and weighed dry with a sensitive balance.

Results and discussion

height Plant trait (cm). results in Table 1. indicate there is Insignificant effect of the difference in faba bean varieties on plant height. While the results obtained from the experiment showed a significant effect of different levels of fulvic acid fertilizer on plant height, it is noted that there is a direct relationship between increasing the fertilizer level and height trait, as level twice recommended concentration give highest significant value for this trait if it amounts to 79.77 cm. reason for this may be that treatment with fulvic acid leads to an increase in vegetative growth, increases permeability of cellular membranes, and improves nutrient absorption, and this is consistent with what

was mentioned (7). two-way interaction of experimental factors had a significant effect on plant height, as highest significant values for this trait were obtained from treating both Spanish and Italian varieties with twice recommended amount of fulvic acid fertilizer, which amounted to 82.22 cm and 77.33 cm, respectively. **number of branches. Plant⁻¹:**

results Table 2. articulate no significant effect of cultivar factor on number of branches per plant. Perhaps this is because the cultivars used in experiment are genetically similar in this trait. While there was a significant effect of the difference in fertilizer levels on number of branches. Plant⁻¹, we note from results that twice recommended concentration was superior in giving highest significant values for this trait, reaching 4.11 branches. Plant⁻¹. may be because treatment with fulvic acid increases permeability of cell membranes and improves nutrient absorption, thus increasing growth through the development of the root and vegetative systems, which leads to an increase in the number of branches, and this is consistent with what was mentioned [26, 27, 28]. results in flesh table showed too a significant bilateral interaction between study factors influencing number of branches. Plant⁻¹, as the Spanish variety, was significantly superior in giving the highest value for this trait, reaching to 4.22 branches. Plant⁻¹, although it did not differ significantly from most of treatments.

number of pods. Plant⁻¹:

clear from Table 3. there is no significant effect of difference in the varieties included in the experiment on the number of pods. Plant⁻¹. Table 3. indicates that the difference in levels of biological fertilization a significant effect on number of pods. Plant⁻¹, as increase in this trait was gradual as the fertilizer concentration increased, reaching the highest significant value at the level of twice the recommended concentration, which amounted to 4.72 pods. Plant⁻¹ compared to the control treatment and other treatments, This may be due to of fulvic acid enhances plant growth and decrease nutritional competition between pods within a single plant, This increases number, as well as to the catalytic role of enzymes and activating vital processes, which has a major role in the assimilation of carbohydrates and protein within the plant and then transporting it to the rest of the plant parts, including the pods, and this is consistent with what was found [29, 27]. results in the same table also appear a significant bilateral interaction for experimental factors, where the highest significant values were for the number pods. Plant⁻¹, when using twice recommended concentration for both the Spanish and Italian varieties, amounted to 4.56 and 4.89 pods. plant⁻¹,

sequentially. **Pod length trait (cm):** Table 4. indicates that is a significant effect of difference between varieties in the pod length trait, as Italian variety was significantly superior in giving highest value for this trait, reaching to 20.16 cm, while lowest significant value was for Spanish variety, reaching to 18.19 cm. The reason this may be due to a difference in the genetic composition of each variety and the extent of each variety's response to prevailing environmental conditions in experimental area. This finding is consistent with previous studies [30, 25]. levels of biofertilizer had a significant effect on the pod length trait, as it is noted that increase was gradual as fertilizer level increased so that the highest level excelled in giving highest values to this trait, which reaching to 21.39 cm compared to control treatment and other treatments. reason for this may be due to role of fulvic acid in enhances plant growth and decrease nutritional competition between pods within a single plant, leading to an increase in length, as well as to catalytic role of enzymes Activating vital processes, which has a major role in cell division and elongation and increasing the representation of carbohydrates and protein within the plant and then transferring it to the rest of the plant parts, including the pods, and this is consistent with what was found [27]. results in same table indicated that was a significant effect of bilateral interaction of the scab factors on the trait of pod length, as highest significant value to this trait was obtained when the Italian bean variety was treated with twice recommended amount of fertilizer, which amounted to 22.11 cm, noting that it did not differ significantly with some treatments.

biological yield trait (gm. m⁻²):

Table 5. indicates that there is a significant effect of the varieties on the biological yield trait, as the Spanish variety excelled in giving highest significant value for this trait, which amounted 504.50 grams. M⁻² compared to Italian variety, which give lowest significant value to this trait, which reaching to 462.33 g. M⁻² reason for this perhaps due to a difference in genetic makeup of each variety and range of each variety's response to the environmental conditions prevailing in the experimental area, and this is consistent with what was found [31,25]. difference in fertilization levels also had a significant effect on biological yield trait, as increase was gradual and significant as the fertilization level increased, reaching the highest significant value at the level of twice the recommended concentration of fulvic acid fertilizer, which amounted to 531.39 grams. M⁻² compared to comparison transaction and other transactions, This may be because fulvic acid contains nitrogen and phosphorus, in addition to micro elements that plant absorbs, which leads to an

increase in vegetative and root growth, and this leads to an increase in rate of photosynthesis, which Causes an increase in its products and their transfer to estuary, where manufactured materials accumulate, which excess weight of the seeds, and this increases weight of the seeds. biological yield as a whole is consistent with what was found [26, 27, 31]. results in same table showed that there was a significant binary interaction between experimental factors in biological yield trait, as highest significant value for this trait was obtained from interaction between the Spanish variety and double the recommended amount of fertilization with fulvic acid, which amounted to 557.11 grams. M⁻².

Seed yield trait (gm⁻²): Table 6. reference there is a significant effect of the varieties used in experiment on the seed yield trait, as the Italian variety excelled in giving highest significant values to this trait, which amounted to 165.25 g. M⁻², compared to the Spanish variety, which gave lowest significant value, which amounted to 155.8 g. M⁻², reason for this is perhaps due to a difference in genetic composition of each variety and range of each variety's response to environmental conditions prevailing in experimental area, and this is consistent with what was found [31, 32]. difference in fertilizer levels has a significant effect on the quality of seed yield. We notice results in Table [6] there is a gradual and significant increase in this trait as the level of fertilization increases, reaching the highest significant value when using double concentration. The recommended amount of fulvic acid fertilizer amounted to 184.61 grams. M⁻² compared to control treatment and other treatments. This is perhaps due to function of fulvic acid in improving the quality of crop, as [33, 25] indicated that organic acids stimulate many enzymes and increase process of photosynthesis. This leads to improved vegetative growth, which is reflected positively in increased carbohydrate and protein synthesis and their accumulation downstream. This leads to an increase in seed weight and thus an increase in total yield, and this is consistent with what was found [34]. results too showed a significant binary interaction between Factors used in experiment, as highest significant value to seed yield was obtained when treated with twice the recommended concentration of fertilizer for the Spanish and Italian varieties, which amounted to 180.89 and 188.33 g. M⁻² compared to other transactions.

Protein%:

Table 7 indicates the presence of a significant effect of the difference in fava bean varieties on the trait of protein percentage in seeds, as the Italian variety outperformed in giving the highest considerable value for this trait, which reached 19.48%. reason for

this may be due to genetic reasons that differ from one variety to another, and this reflects variety's response to environmental conditions and fertilization, which is consistent with [32]. As shown by results, difference in fertilizer concentrations has a significant effect on the percentage of protein in fava bean seeds, as we notice that the relationship was directly proportional between fertilizer and protein percentage, as higher percentage of fertilizer, higher percentage of protein, as the highest significant value was obtained when fertilizing with a concentration of 400 grams of fulvic acid, which reached 20.71%, and the reason for this may be that the fulvic acid improves It increases nitrogen absorption and the number of root nodules in fava bean roots, which enhances atmospheric nitrogen fixation and raises the protein content in seeds, increases photosynthetic efficiency and chlorophyll content, which enhances protein synthesis and deposition in seeds. This is consistent with [33, 25]. results too indicate a significant two-way interaction between experimental factors, as highest protein percentage was obtained significantly when the Italian variety was treated with a concentration of 400 grams of fulvic acid fertilizer, which amounted to 22.25% compared to the other treatments.

Conclusions: From the results obtained, we find that the Italian fava bean variety was more responsive to fulvic acid, especially when treated at a concentration of 400 mg/D.

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Table 1. shows effect of varieties and fulvic acid fertilization on height of bean plants (cm).

Varieties	Fertilizer level				Effect of varieties
	Control	100 gm ⁻¹	200 gm ⁻¹	400 gm ⁻¹	
Spanish	63.11 cd	64.00 cd	70.67 bc	82.22 a	70.00 a
Italian	59.67 d	64.77 cd	72.33 b	77.33 ab	68.52 a
Fertilizer effect	61.39 c	64.39 c	71.50 b	79.77 a	

Values followed by symmetric letters not significantly different from each other at 5% probability level.

Table 2. shows effect of varieties and fulvic acid fertilization on number of branches. Plant¹.

Varieties	Fertilizer level				Effect of varieties
	Control	100 gm ⁻¹	200 gm ⁻¹	400 gm ⁻¹	
Spanish	3.11 b	3.55 ab	3.89 ab	4.22 a	3.69 a
Italian	3.22 ab	3.22 ab	3.77 ab	4.00 ab	3.55 a
Fertilizer effect	3.16 b	3.38 b	3.83 ab	4.11 a	

Values followed by symmetric letters not significantly different from each other at 5% probability level.

Table 3. shows effect of varieties and fulvic acid fertilization on number pods. Plant¹.

Varieties	Fertilizer level				Effect of varieties
	Control	100 gm ⁻¹	200 gm ⁻¹	400 gm ⁻¹	
Spanish	3.89 ab	3.66 ab	4.00 ab	4.56 a	4.03 a
Italian	2.89 b	3.89 ab	4.46 a	4.89 a	4.02 a
Fertilizer effect	3.39 b	3.77 b	4.22 ab	4.72 a	

Values followed by symmetric letters not significantly different from each other at 5% probability level.

Table 4. shows effect of varieties and fulvic acid fertilization on pod length (cm).

Varieties	Fertilizer level				Effect of varieties
	Control	100 gm ⁻¹	200 gm ⁻¹	400 gm ⁻¹	
Spanish	14.67 c	18.00 b	19.44 ab	20.67 ab	18.19 b
Italian	19.33 ab	18.88 ab	20.33 ab	22.11 a	20.16 a
Fertilizer effect	17.00 c	18.44 bc	19.88 ab	21.39 a	

Values followed by symmetric letters not significantly different from each other at 5% probability level.

Table 5. shows effect of varieties and fulvic acid fertilization in biological yield (g m²).

Varieties	Fertilizer level				Effect of varieties
	Control	100 gm ⁻¹	200 gm ⁻¹	400 gm ⁻¹	
Spanish	446.67 de	489.56 bcd	524.67 ab	557.11 a	504.50 a
Italian	415.00 e	451.67 de	477.00 cd	505.67 bc	462.33 b
Fertilizer effect	430.83 d	470.61 c	500.83 b	531.39 a	

Values followed by symmetric letters not significantly different from each other at 5% probability level.

Table 6. shows the effect of varieties and fulvic acid fertilization on seed yield (g m⁻²).

Varieties	Fertilizer level				Effect of varieties
	Control	100 gm ⁻¹	200 gm ⁻¹	400 gm ⁻¹	
Spanish	137.55 c	147.55 c	157.33 bc	180.89 a	155.8 b
Italian	146.00 c	155.33 bc	171.33 ab	188.33 a	165.25 a
Fertilizer effect	141.77 c	151.44 bc	164.33 b	184.61 a	

Values followed by symmetric letters not significantly different from each other at 5% probability level.

Table 7. shows effect of varieties and fulvic acid fertilization on Protein % in seeds.

Varieties	Fertilizer level				Effect of varieties
	Control	100 gm ⁻¹	200 gm ⁻¹	400 gm ⁻¹	
Spanish	16.57 e	16.60 e	17.88 d	19.18 bc	17.56 b
Italian	17.45 de	18.40 cd	19.81 b	22.25 a	19.48 a
Fertilizer effect	17.01 c	17.50 c	18.84 b	20.71 a	

Values followed by symmetric letters not significantly different from each other at 5% probability level.