Research Article

Effect of Different Fertilizer Regimes on Some Vegetative and Yield Related Traits of Faba Beans (*Vicia faba* L.)

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Abstract | Faba bean (*Vicia faba* L.) is a significant leguminous crop cultivated in many countries, including Iraq. As organic fertilization is an effective strategy to enhance the soil physico-chemical characteristics and the bioavailability of nutrients to the crop plants, this field trial aimed to assess the comparative effects of chemical (mineral) and organic fertilizers on the vegetative and yield-related characteristics of *V. faba* plants. The experiment involved three fertilizer treatments (*i.e.,* organic fertilizer and DAP fertilizer applied @ 500 kg ha^{-1} either alone or in combination) and a control treatment. The results showed that the interaction treatment, involving the combined application of both type of fertilizers, exhibited the highest values for all studied plant parameters including plant height, leaf area, stem diameter, number of branches $plant^{-1}$, number of seeds pod^{-1}, number of pods $plant^{-1}$, weight of 100 seeds, and total yield ha^{-1} which were 109.33 cm, 20.57 cm^2, 4.66 mm, 15.33, 7.0, 24.66, 44.46 tons ha^{-1} and 127.33 g, respectively. Overall study results indicate that the administration of organic and mineral fertilizers, particularly in their combined application, would play an effective role in improving the growth and yield characteristics of faba bean plants.

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Introduction

Faba bean (*Vicia faba* L.) is one of the major leguminous crops being widely grown for both human and animal consumption (Bangar and Kajla, 2022). These beans are also known as broad beans and have a high nutritional value with substantial protein and fiber contents ranging from 25–40 and 5–8.5%, respectively. Faba beans are excellent alternative and a cheaper source of dietary protein as compared to costly animal proteins, particularly in developing countries such as in Africa and Asia (El-Yazal, 2020; Maalouf *et al*., 2021). Moreover, *V. faba* plants can ameliorate the physico-chemical and biological characteristics of the soil because of the important characteristic of fixation of atmospheric nitrogen through symbiosis with *Rhizobium* bacteria (Mekki, 2016; Aschi *et al*., 2017; Jithesh *et al*., 2024).

In Iraq, major *V. faba* cultivating areas include the Governorates of Nineveh, Baghdad, and Babylon, covering an area of about 6200 hectares (MoP, Iraq, 2020). with an average yield of 5240 tons per annum (Jasim *et al*., 2016; Bashar *et al*., 2025). Bean

cultivation in Iraq still suffers from many problems that have led to a decline in production per unit area (Qasim, 2024). Perhaps the most prominent of these problems is are lack of soil fertility and crop productivity. Fertilization processes and their timing are at the forefront of these problems, as they affect many traits that influence crop production. Providing adequate fertilization to a crop can reduce the flower drop and increase the production. Usage of chemical and organic fertilizers has become a vital strategy for improving crop growth and increasing productivity (Chinthapalli *et al*., 2015; Liu *et al*., 2024).

Moreover, organic fertilizers, such as compost, animal manure, and plant waste materials, improve the physico-chemical characteristics of the soils along with an enhancement of the edaphic microbial activities, which ultimately positively impacts the nutrients' bioavailability and absorption by crop plants (Tian *et al*., 2022; Liu *et al*., 2024). In contrast, the chemical fertilizers provide rapidly absorbable nutrients to plants, particularly nitrogen, phosphorus, and potassium, but their excessive use can lead to soil degradation and environmental imbalance (Pahalvi *et al*., 2021). Organic fertilization is the foundation for increasing agricultural production and reducing environmental pollution resulting from the excessive application of different chemical and mineral fertilizers (Verma *et al*., 2019). Therefore, the usage of plant and animal wastes is essential for providing the required quantities of organic fertilizers to meet agricultural land needs (Gomaa and Afifi, 2021). The use of organic fertilizers has an indirect effect on the prevailing biological and physico-chemical properties of soils. Organic fertilizer is considered an important aspect of modern agriculture, particularly in sandy soils that are poor in organic matter (Brempong and Addo-Danso, 2022). Furthermore, it reduces the loss of nutrients from intensive irrigation, as organic matter is characterized by its ability to absorb both micro and macronutrients, making them more readily available in the rhizospheric zone (Pashaki *et al*., 2016; Al-Leela *et al*., 2019; Bashir *et al*., 2021).

One of the major chemical nutrients required by crop plants is phosphorus. It has a crucial role in plant physiology, regulating the biochemical processes of photosynthesis, respiration, and cell division (Khan *et al*., 2023). It is essential for root formation, flowering, and fruit development, and has a direct role in ADP and ATP synthesis (Rugheim and Abdelgani, 2012; Liu *et al*., 2022). Without sufficient phosphorus, plants cannot grow normally. Previous studies have used various methods to increase phosphorus availability in the soil, including different management methods to provide this element and the use of chemical fertilizers, which have achieved a 30-50% increase in yield (Al-Khafaji *et al*., 2018; Jasim and Mhanna, 2014). It is essential to ensure adequate concentrations of phosphorus in the soil and in a form readily available to the plant.

Therefore, this study aimed to assess the impact of different chemical and organic fertilizers on the productivity, growth rate, and seed quality of faba beans based on recent scientific studies. This study is important in identifying the most sustainable methods for growing fava beans, especially in light of the global trend toward organic farming and reducing chemical pollution.

Materials and Methods

Study site

This study was done at the farm area of the Suwaira Technical Institute, Department of Plant Production Technologies, located at a latitude of 31.50° N and longitude of 9.75° W, at an elevation of 11° above sea level.

Table 1: *Some physical and chemical properties of the study soil.*

Soil characteristics	Units	Values
pH		7.9
EC	$DeS.m^{-1}$	3.9
Organic matter	$g.kg^{-1}$ soil	1.2
Ca^{+2}	m. mol $.L^{-1}$	10.8
Mg^{+2}		5.36
K^{+}		0.54
Na^{+}		5
Cl^{-1}		15.8
SO_4^{-}		1.13
CO_3^{-}		Nil
HCO_3^{-}		4.5
Available nitrogen	mg. kg $soil^{-1}$	25.22
Available phosphorus		14.5
Available potassium		160.8
Soil texture	$g.kg^{-1}$	Silty loam (sand, silt and clay @ 180, 700 and 120, respectively)

Experimental layout

Faba bean plants were planted on November 6, 2024, in an agricultural field with silty loam soil (Table 1). The experimental layout was according to a randomized complete block design (RCBD). The first factor was the administration of an organic fertilizer @ 500 kg ha^{-1}. The second factor was chemical fertilizer (DAP administered @ 500 kg ha^{-1}) and a combined application of both organic and chemical fertilizer, with three replicates. Control treatment was without any type of fertilization. The size of the experimental unit area was about 2.25 m^2. The land was plowed using a rotary plough, smoothed, and leveled. Plants were sown in rows with a spacing of 70 cm between rows. The seed rate used was 10 kg ha^{-1}. Phosphate fertilizer was added @ 250 kg ha^{-1} at the plantation time, while nitrogen fertilizer was administered twice, firstly at the planting stage and secondly at the beginning of the flowering stage. The crop was irrigated as needed throughout the season until harvest.

Table 2: *Effect of different fertilizer regimes on some vegetative characteristics of faba beans ((Vicia faba) plants.*

Treatments	Number of branches $plant^{-1}$	Plant height (cm)	Leaf area (cm^2)	Stem diameter (mm)
Control	8.66	60.33	6.88	2
DAP	14.66	79	13	4
OM	12.33	72.33	7.88	3
DAP+OM	15.33	109.33	20.57	4.66
LSD	1.45	7.39	3.23	0.29

DAP = diammonium phosphate @ 500 kg ha-1; OM = organic manure 500 kg ha-1

Upon maturity, the crop was harvested from randomly selected one-meter rows from each treatment plot, and the morphological and productive characteristics of the crop were measured. From each experimental unit, three plants were randomly selected, harvested and weighed, and the seeds were counted. The dry weight of the plants was measured on the experimental plot, and the weight of the seeds was determined using a digital weigh balance.

Statistical analysis

The data regarding the vegetative and yield traits of plants were statistically analyzed using STATISTIX 8.1. Factorial analysis of variance (ANOVA) was used to determine the significance of the factors, followed by the comparison of treatment means using the least significant difference (LSD) post-hoc test at a standard (5%) level of significance.

Results and Discussion

Impact of treatments on the vegetative growth traits of faba bean plants

Statistical analysis of the data exhibited significant differences between the fertilizer types. However, no significant difference was observed regarding the effect of the interaction or combined application of treatments on the studied plant growth parameters (Table 2). The interaction of both fertilizer types exhibited the maximum average branch numbers $plant^{-1}$ (15.33 branches $plant^{-1}$), while the control treatment exhibited the minimum branch numbers (8.66 branches $plant^{-1}$). This indicates that organic matter had an impact on the availability of nutrients and improved the absorption of the added DAP fertilizer (El-Mahdy *et al.*, 2021), and it exhibited the maximum results in branch number (Table 2). Regarding average plant height, no significant differences were recorded between the control treatment and the DAP fertilization treatment. The interaction treatment of organic and mineral fertilizers exhibited maximum plant height (109.33 cm), while the control treatment exhibited the minimum plant height of 60.33 cm. Regarding the stem diameter, the interaction treatment exhibited the maximum stem diameter (4.66 mm), while the control treatment showed the minimum stem diameter (2 mm). This indicates that increased phosphorus availability, which in turn supported the increased stem diameter, is beneficial to the plant, as organic matter provides the greatest benefit to the plant from absorbing the added phosphorus, which works to resist plant lodging and grow more efficiently (Chinthapalli *et al.*, 2015; Crous *et al.*, 2015).

Similarly, a significant difference was recorded between the control treatment and the chemical fertilization treatment, showing 6.88 and 13 cm^2, respectively. Significant differences were recorded among the binary and organic matter treatment and the control treatment, which yielded the highest leaf area of 20.57 cm^2. There were no significant differences between the organic matter treatment and the control treatment. The interaction treatment exhibited the highest leaf area of 20.57 cm^2 (Table 2). Leaf area increment actually increases the yield of the plants.

The leaf is considered the primary source of plant nutrition, as it hosts all vital processes from organic synthesis and energy conversion to the plant, and is the source of nutrient absorption and respiration through the stomata. The fertilization treatment, which utilizes organic matter, helps to increase the availability of added phosphorus, resulting in higher plant vegetative growth, both in terms of plant height and leaf area (Mohamed and Gomaa, 2005; Fekadu *et al.*, 2018; Ahmed *et al.*, 2023).

Table 3: *Effect of different fertilizer regimes on some yield-related characteristics of faba beans ((Vicia faba) plants.*

Treatments	Number of pods plant^{-1}	Number of seeds pod^{-1}	Weight of 100 seeds (g)	Total yield (tones ha^{-1})
Control	17	3	68	6.50
DAP	21	5	134	19.23
OM	23.33	5	113	19.00
DAP+OM	24.66	7	127.33	44.46
LSD	1.59	2.23	4.35	2.26

DAP = diammonium phosphate @ 500 kg ha-1; OM = organic manure 500 kg ha-1

Impact of fertilization treatments on yield-related traits of faba bean plants

Analysis of results depicted significant differences between the control treatment and fertilizer treatments (Table 3). The interaction treatment exhibited the maximum number of pods plant^{-1} (24.66 pods plant^{-1}), not significantly different from the organic matter treatment (23.33 pods plant^{-1}), while the control treatment exhibited the minimum number of pods (17 pods plant^{-1}). These differences indicate that organic matter increases the availability of nutrients and phosphorus added to the soil and their absorption by the plant, which results in higher flowering and a higher number of pods per plant, as demonstrated by some previous studies (Chafi and Bensoltane, 2009; Dhary and Al-Baldawi, 2017; Yasmin *et al.*, 2020; Chimdi *et al.*, 2022).

Similarly, the interaction treatment exhibited the maximum number of seed pod^{-1} (7 seeds), while the control treatment exhibited the minimum number (3) of seed pod^{-1} (Table 3). Similarly, no significant difference was recorded among mineral or chemical, and organic fertilizers and their interaction treatment. Organic fertilizer would increase the phosphorus uptake, which would increase the seed numbers pod^{-1}. As mentioned in previous studies, phosphorus plays a role in disease resistance, flower fertilization, and seed formation and maturation (Fouda, 2017; Liu *et al.*, 2022; Khan *et al.*, 2023). Moreover, the maximum and minimum average weight per 100 seeds were recorded for the interaction and control treatments, *i.e.*, 127.33 and 68 g, respectively. The organic and mineral fertilizer treatments yielded 113 and 134 g, respectively. Regarding the total yield of faba beans, the maximum yield was exhibited by the interaction treatment (44.46 tons ha^{-1}), while there was no significant difference between the two fertilizer types. The minimum total yield was recorded for the control treatment (6.50 tons ha^{-1}) (Table 3).

Overall, there was no significant differences between the types of fertilizer treatments. However, there were significant differences between the two treatments and the interaction treatment. This difference indicates that organic fertilization improves soil properties and increases soil moisture, which upsurges the absorption of nutrients from the soil and increases the amount of added phosphorus, which improves the yield (Dhary and Al-Baldawi, 2017). These results corroborate the fact that organic fertilization increases the availability of nutrients, which in turn increases seed weight, which positively impacts the overall yield of the plant (Agegnehu *et al.*, 2005; Osman *et al.*, 2010; Abbas, 2013; Cucci *et al.*, 2019).

Conclusions and Recommendations

Based on overall study results, it is concluded that the administration of organic and mineral fertilizers, particularly in interaction, would play an effective role in improving the growth characteristics, such as leaf area, number of branches per plant, and plant height. The mineral and organic fertilizers indeed play a crucial role in increasing yields, including the weight of 100 seeds, the number of seeds per pod, and the number of pods per plant, which is reflected in an increase in the total yield. These fertilizers complement each other, and their combined application yielded the maximum values of all studied parameters of faba bean plants.

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Novelty Statement

This research is the interaction treatment, involving the combined application of both type of fertilizers, exhibited the highest values for all studied plant parameters including plant height, leaf area, stem diameter, number of branches plant^{-1}, number of seeds pod^{-1}, number of pods plant^{-1}, weight of 100 seeds, and total yield ha^{-1}.

Generative AI or AI assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Conflict of interest

The authors have no conflict of interest.

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