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Research article

Impact of various organic compost and biochar blends on the growth of *Vicia faba* L.

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ABSTRACT

During the 2024–2025 growing season, the Dhi Qar Province's College of Agriculture and Marshes carried out an experiment. Three replicates of each treatment were used in our completely randomized design (CRD). C0B0 (no compost, no biochar), C1B1 (4 t·ha^{-1} compost + 2.5% biochar), C2B2 (6 t·ha^{-1} compost + 5% biochar), C3B3 (8 t·ha^{-1} compost + 10% biochar), and C4B4 (10 t·ha^{-1} compost + 15% biochar) were the five combinations that were tested. At the time of planting, both amendments were added to the soil. Pots with 4 kg of substrate were filled with seeds of a local landrace of faba beans. To observe how these blends impact growth under container conditions, we counted the number of leaves, branches, flowers, and plant height. Our results show that the combined effects of compost and biochar on growth traits are concentration-dependent. Treatment C4B4 produced the tallest plants (43.00 cm). Treatment C3B3 produced the most branches per plant (9.33) and the greatest leaf count (292.00 leaves per plant). The most flowers (79.00 per plant) were produced by the treatment (C4B4). Increased application rates, particularly for C3B3 and C4B4, enhanced the vegetative and reproductive development of faba beans when these treatments were combined. These findings lend credence to the notion that, in controlled environments, integrated organic amendments can improve crop performance.

1. Introduction

In today's world which is battling for food security and soil erosion, pulses play a critical role in the global agriculture system. Broad beans (*Vicia faba* L.) belong to the most important crops. They are visited by honey bees (Apis cerana F.) and are regarded as being of great importance as sources of proteins for the populations of developing provinces of the world, such as the Middle East and North Africa, in whose countries they are cultivated. Their seeds have protein content from 24% to 35% of dry matter (Lundby et al., 2024) and serve as strategic food crops that are able to supply protein to humans and animals (Ehsani et al., 2024). Their use is not limited to feeding and fodder; their contribution to the environment and agriculture is also important for achieving sustainable production systems.

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By utilizing the biological nitrogen fixation system, broad beans, along with the Rhizobia bacteria, are able to fix a large amount of N (Huang, 2024) into the soil, safe from the addition of chemical fertilizers. This process helps replenish N lost due to root absorption, leaching and denitrification. In addition, broad beans can also crop as cover crops which can help to prevent erosion and build up soil structure. The inter-crop rotation with legumes generates nitrogen reserves for next crops such as cereals (Cerveny et al., 2023).

Organic fertilizers have been gaining more and more attention as an alternative or a complement to chemical fertilizers for sustainability. Water use efficiency, bulk density and total porosity all benefited from the addition of organic material (Habtamu et al., 2024). Furthermore, the use of organic fertilizers enables a gradual release of nutrients over time due to microbial processes, providing a sustainable nutrient supply that is released over time (Mohite et al., 2024). The use of seaweed powder as bio-enhancer in the growth parameters of broad bean: plant height, branch numbers, leaf area and dry weight resulted in positive enhancement (Al-Zubaidy, 2023).

The agricultural pressure remains on land and the land condemning to agricultural production, is being masked by the problem of fertility depletion during land reclamation (Gupta et al., 2023). The challenge is to attain a productivity-increase without conventional intensification that involves the increased degradation of resources. Balancing soil health and production through integrated management practices is key to the solution.

Biochar is the material obtained by the thermal decomposition of organic matter under oxygen-deficient conditions and it is not used as a fuel, but as a soil conditioner (Park et al., 2023). Positive effects on the chemical properties of soils have been reported, among which are improvements in soil pH in acidic soils (Mao et al., 2024), improvements in availability of nutrients (Bekchanova et al., 2024), increase in water holding capacity (Abd El-Moaty et al., 2024) and increase in cation exchange capacity (Nafees et al., 2023). Responses to crop growth have been reported with faba beans (Abd El-Moaty et al., 2024). However, in broad bean the studies of biochar with organic fertilizers are limited.

The biochar consists of porosity at a high level, which promotes microbial life in the porous structure and can improve the mineralization of organic fertilizers (Hu et al., 2024). Consequently, biochar and organic fertilizers are a suggested solution that should be subject to thorough testing. This study assessed various treatments of biochar and organic fertilizer for the growth and yield of broad bean in terms of soil physical, chemical, and biological properties. The results of the survey will contribute to the sustainable production of broad beans without using chemical fertilizer.

2. Materials and Methods

2.1. Experimental location and growing season

This study was carried out using pots during winter season 2024-2025 at the College of Agriculture and Marshes, University of Dhi Qar, Nasiriyah, Iraq. The rooting volume was standardized into pots (4 kg), and the heterogeneity of the soil in space was minimized. The soil is found in arid climates. The physical and chemical properties of the soil are summarized in Table1.

Table 1. Some initial physical and chemical properties of the studied soils

Parameter	Before fertilization	After fertilization
pH	7.4	7.9
Electrical conductivity (dS/m)	1.5	6.1

Texture	Sandy loam	Sandy loam
Total nitrogen (ppm)	20	60
Available phosphorus (ppm)	2	15
Available potassium (ppm)	75	270

Representative samples of compost and biochar were analyzed for pH, electrical conductivity (EC), total nitrogen (N), phosphorus (P), potassium (K) and organic matter content. The detailed properties are shown in Table 2.

Table 2. Physicochemical properties of compost and biochar used in the study.

Property	Unit	Compost	Biochar
pH	**-**	**6.5**	**7.3**
Electrical conductivity (EC)	**$dS{\cdot}m^{-1}$**	**3.20**	**0.21**
Total nitrogen (N)	**%**	**3.5**	**0.53**
Total phosphorus (P)	**%**	**1.5**	**1.02**
Total potassium (K)	**%**	**2.5**	**0.24**
C:N ratio	**-**	**18:1**	**23:1**
Source	**-**	**Cow manure**	**Wood stem**

2.2. Plant material

Vicia faba L. (broad bean) was seeded on Nov. 22, 2024 in open field 4 kg plastic pots. Crop maturity occurred on April 15, 2025 (≈145 days), which occurred as scheduled according to the Iraq's winter crop maturation schedule in the south.

2.3. Experimental treatments

There were five fertilization treatments tested (Table 3). The compost and the biochar were added to the potting soil at sowing. The investigation was focused on the effects of various compost–biochar mixtures and did not include treatments with biochar alone or compost alone.

Standard agronomic assumptions were used for field application rates to calculate pot-based amounts (4 kg soil/pot). The assumption for the composting depth was 20 cm (0.2 m) and the bulk density of the mineral soil 1.2 $t{\cdot}m^3$. The soil mass per hectare under these circumstances is 10,000 m^2 × 0.2 m × 1.2 $t{\cdot}m^{-3}$ = 2,400 t. Thus, 1 $t{\cdot}ha^{-1}$ of compost is equivalent to 1/2,400 = 0.0004167 t of compost per t of soil, or 0.4167 g of compost per kg of soil. This results in 4 × 0.4167 = 1.667 g of compost per 1 $t{\cdot}ha^{-1}$ application rate for a 4 kg pot. It was assumed that the percentage of biochar was weight/weight (w/w) in relation to the weight of the soil. Therefore, 2.5% biochar is equivalent to 0.025 × 4000 g soil = 100 g biochar per pot; similarly, 5%, 10%, and 15% are equivalent to 200 g, 400 g, and 600 g biochar per pot, respectively.

Table 3. Fertilization treatments combining graduated rates of compost and biochar

Code	Level	Compost ($t{\cdot}ha^{-1}$)	Biochar (% (w/w)
C0B0	Control	0 (0 g/pot)	0 (0g/pot)
C1B1	Low	4 (6.67g/pot)	2.5 (100g/pot)
C2B2	Medium	6 (10.00g/pot)	5.0 (200g/pot)
C3B3	High	8 (13.34g/pot)	10.0 (400g/pot)

C4B4	Very high	10 (16.67g/pot)	15.0 (600g/pot)

2.4. Experimental design

The treatments were laid out in a completely randomized design (CRD) having three replications (15 experimental units).

2.5. Agronomic management

The pots were watered when the soil surface 2 to 3cm below was evident of being light and dry. When seedlings had germinated and reached about 5 cm tall, they were thinned. Manual elimination of weeds was done.

2.6. Statistical analysis

The CRD model was used to analyze data in SPSS v.25. Fisher's least significant difference (LSD) test ($P \leq 0.05$) was used to separate means in treatment.

3. Results

3.1. Plant height (cm)

There was a significant variability of the growth of the plants of C4B4 compared to control C0B0 (Table 4), with its growth reaching 43.00 cm against 15.00 cm in C0B0.

3.2. Number of leaves plant^{-1}

The maximum leaf number on a plant was found for C3B3 (292.00 leaves plant -1) followed by control (134.33 leaves plant -1) (Table 4).

3.3. Number of branches plant^{-1}

The control has 5 branches/plant while C3B3 has a much higher number of branches (9) per plant (Table 4).

3.4. Number of flowers plant^{-1}

Treatment response pattern was further revealed by flower number, the treatment (C4B4) had the highest treatment mean of 79.00 flowers plant^{-1} while the control having the lowest treatment mean of 24.00 flowers plant^{-1} (Table 4).

Table 4. Effect of compost and biochar fertilization on traits of faba bean

Treatment	Plant height (cm)	Leaves plant^{-1}	Branches plant^{-1}	Flowers plant^{-1}
C0B0	15.00	134.33	5.33	24.00
C1B1	29.33	139.00	7.33	29.33
C2B2	35.66	140.33	9.00	45.33
C3B3	41.66	292.00	9.33	58.66
C4B4	43.00	177.66	7.33	79.00
LSD (0.05)	17.22	107.19	1.87	27.16

3.5. Shoot fresh weight (g plant^{-1})

There was no significant effect observed (Table 5). The means ranged from 75.66 (C0B0) to 127.00 (C4B4), with differences below the LSD threshold (P > 0.05).

3.6. Shoot dry weight (g plant^{-1})

There was no significant difference noted (Table 5).

3.7. Root fresh weight (g plant^{-1})

There was no significant response (Table 5).

3.8. Root dry weight (g plant^{-1})

Table 5 shows that significant treatment effects do not exist. The highest mean was under C4B4 (27.20 g plant^{-1}), and C1B1 gave the lowest (14.61 g plant^{-1}), even below the control (20.03).

3.9. Root length (cm)

There was no significant response was seen, (Table 5).

Table 5. Effect of compost and biochar on root and shoot biomass

Treatment	Root length (cm)	Root dry weight (g plant^{-1})	Root fresh weight (g plant^{-1})	Shoot dry weight (g plant^{-1})	Shoot fresh weight. (g plant^{-1})
C0B0	48.66	20.03	41.66	13.16	75.66
C1B1	34.33	14.61	48.66	18.06	104.00
C2B2	30.00	16.30	34.00	15.53	122.33
C3B3	36.66	19.80	49.33	22.53	108.33
C4B4	46.66	27.20	57.66	9.88	127.00
LSD (0.05)	N.S.	5.73	N.S.	N.S.	N.S.

4.Discussion

4.1 Combined effect of compost and biochar effects on vegetative growth

The use of compost and biochar together significantly increased plant height, leaf number, branching, and flowering in a dose-dependent manner (Table 4). Because of the porosity that biochar adds, these improvements can be broadly attributed to improved nitrogen mineralization, increased water-holding capacity, and decreased bulk density. Furthermore, more branches under C3B3 may be a sign of improved phosphorus supply, which promotes lateral bud release (Liu et al., 2024).

4.2 Non-significant root and shoot biomass responses

Shoot fresh and dry weights, root fresh weight, and root length did not significantly differ between treatments, in contrast to the beneficial effects on growth traits (Table 5). The comparatively brief growing season in pots may restrict nutrient mineralization, which could explain the lack of significance in shoot fresh weight (Liu et al., 2024). Similarly, the physical limitations imposed by the 4 kg pots may be the reason for the lack of a significant impact on root length (Helaoui et al., 2023).

4.3 Comparison with previous studies

Our results on shoot dry weight are opposite to those reported by Abd El-Mageed et al., (2021), who found higher availability of compost. This discrepancy could be attributed to differences in maturity of the compost, amendment rate, or rooting volume. In contrast, the non-significant effect on root fresh weight is in agreement with Amaral et al., (2019) for biochar, but not for compost.

4.4 Beneficial effects on root dry weight

The results of this study show that the organic fertilizer and biochar mixture (C4B4) is an ideal soil amendment for promoting bean growth and yield under the tested conditions. These results warrant further investigation using factorial designs to interpret the observed effects. This is probably due to improved aeration and porosity (Egamberdieva et al., 2020), which can stimulate root development despite low total root length.

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