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Effect of Concentration and Application Method of Compost Tea (Buffalo Manure Extract) on Green Broad Bean Yield and Growth *Vicia faba* L.

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ABSTRACT

Faba beans (Vicia faba L.) are an important legume crop known for their high protein content and ability to improve soil health through nitrogen fixation. This research aimed to analyze the effects of different application methods and concentrations of buffalo manure compost tea on the growth and productivity of the Luz de Otoño faba bean cultivar. A field experiment was conducted during the winter season of 2023–2024 using a randomized complete block design (RCBD) with three replications. The trial examined two factors: the method of application (soil drenching versus foliar spray) and the concentration of compost tea (0, 100, and 200 mL L^{-1}). The compost tea was prepared through controlled aerobic fermentation of buffalo manure, adhering to all relevant agronomic principles. Statistical analyses of vegetative growth, yield, and physiological measurements were performed using GenStat, with treatment means compared through Least Significant Difference (LSD) at a significance level of $p \leq 0.05$. The study's findings indicated that the application method and compost tea concentration significantly affected the growth characteristics measured. Soil drenching consistently outperformed foliar spraying, leading to significant increases in various growth metrics: plant height (15.13%), number of branches (23.69%), leaf area (53.87%), shoot dry weight (71.57%), pod weight (81.70%), and chlorophyll content (13.73%). A strong dose-response relationship was noted, with the 200 mL L^{-1} concentration yielding the highest improvements, including a 46.15% increase in pod length and an 88.8% increase in leaf carotene compared to the control. Additionally, a significant interaction between the application method and concentration was observed for pod weight and pod length, with soil drenching at 200 mL L^{-1} proving to be particularly effective.

Keywords: Faba bean, Organic fertilization, Compost tea, Buffalo manure, Growth and yield

INTRODUCTION

Broad beans (*V. faba* L.), belonging to the Fabaceae family, are an important winter legume crop and a major source of protein and energy in human nutrition. They contain a substantial amount of protein and a considerable percentage of crude fiber (5.0–5.8%), making them a low-cost and accessible alternative to animal protein, particularly for populations with limited resources. In addition to their nutritional value, faba beans contribute significantly to improving soil properties through their ability to fix atmospheric nitrogen in the soil [1].

Enhancing plant growth and productivity requires the adoption of scientifically advanced agricultural practices. Fertilization is one of the most critical factors influencing crop performance. In particular, organic fertilization—when properly managed in terms of application method and rate—plays a key role in improving soil fertility and plant productivity. Buffalo manure has been reported to contain beneficial microorganisms such as *Pseudomonas* and *Proteus mirabilis*, which can enhance plant growth by increasing the availability of essential nutrients [2, 3]. For instance, studies on *Foeniculum vulgare* (dill) demonstrated that the use of buffalo manure increased the number of main branches by 99.32%, lateral branches by 98.32%, and dry matter by 31.45%, as well as elevating the plant's phosphorus, potassium, sulfur, and nitrogen content. These effects were attributed to the microbial activity and nutrient richness of buffalo manure, including phosphate-solubilizing and nitrogen-fixing bacteria such as *Azotobacter*.

Other research also highlighted the advantages of organic liquid fertilizers, including compost and manure teas. The use of poultry compost tea (5 kg/20 L distilled water) significantly increased plant height, leaf number, leaf area, and both root and shoot dry weights compared with cow compost tea [4, 5]. Additionally, this treatment enhanced chlorophyll concentration, nitrate and carotene content, vitamin C, soluble carbohydrates, and mineral accumulation (N, Ca, K, P, Fe), ultimately resulting in higher yields. Similarly, applying poultry manure compost at 3 t ha^{-1} led to significant increases in plant height, dry weight, and total seed yield compared with the control [6].

Comparable outcomes were reported in faba bean studies, where compost, compost tea, and vermicompost tea applications improved plant growth and yield. Vermicompost tea, in particular, produced the greatest increases in branch number and plant height, while compost treatment enhanced fresh weight significantly [7]. The application of poultry manure at 5 t ha^{-1} in *V. faba* (Barcelona variety) also improved plant height, branch number, dry matter, and chlorophyll content [8, 9]. Moreover, poultry and cow manure applications, as well as granular humus, resulted in increased pod yield, plant height, leaf area, pod number, and pod weight compared with control treatments [10].

Organic fertilization has also been shown to improve performance across faba bean varieties, including local, French, and Turkish cultivars. Plants treated with organic fertilizers exhibited higher seed weight per pod, green seed yield, leaf area, and pod length and weight relative to untreated plants [11]. In terms of application method, soil drenching of compost tea has proven more effective than foliar spraying, as it significantly increased leaf number, yield, seed weight, and pod number, while enhancing soil fertility and disease resistance [12]. Similar results were observed for the *Nubaria 1* and *Nubaria 2* varieties, where both compost and compost tea applications positively affected growth and yield parameters [13].

Despite the proven benefits of compost tea, limited information exists regarding the use of buffalo manure compost tea and the influence of its application method and concentration on faba bean performance. Therefore, this study aims to evaluate the effect of different application methods (soil drenching vs. foliar spray) and concentrations (0-, 100-, and 200-mL L^{-1}) of buffalo manure compost tea on the growth, physiological characteristics, and yield of the *Luz de Otoño* faba bean cultivar [13].

Broad beans (*V. faba* L.) come from the Fabaceae family and represent an important winter legume crop and a major source of protein and energy in human nutrition. They have high protein content and a considerable percentage of crude fibers (5.0–5.8%), thus providing a cheap and accessible replacement for animal protein for resource-limited populations. Aside from their nutritional value, the soil properties of faba beans benefit greatly by fixing atmospheric nitrogen in the soil [1]. Advocating for agricultural practices that are scientifically advanced will help increase plant growth and productivity. One of the key determinants of crop performance is fertilization. Soil fertility and plant productivity are particularly benefited when organic fertilization is properly managed in terms of application method and rate. Buffalo manure has been found to be friendly to microorganisms like Pseudomonas and Proteus mirabilis that promote growth by enhancing nutrients [2, 3].

For example, buffalo manure in a study of Foeniculum vulgare (dill) was found to increase the number of main branches by 99.32%, lateral branches by 98.32%, and dry matter by 31.45%, further increasing the phosphorus, potassium, sulfur, and nitrogen (P-K-N) content of the plant. These effects were ascribed to the microbial activity and nutrient diversity of buffalo manure, including phosphate-solubilizing (P-solubilizing) and nitrogen-fixing bacteria such as Azotobacter. Other studies found that the beneficial effects of organic liquid fertilization of the soil, such as compost and manure teas, were consistent with those reported by other studies. Compared to cow compost tea, the application of poultry compost tea (5 kg/20 L distilled water) resulted in high rates, raised plant height, leaf number, leaf area, and roots and shoot dry weight (root and shoot dry weights) [4, 5]. Besides, it also improved chlorophyll, nitrate, carotene content, vitamin C, soluble carbohydrates, and mineral contents (N, Ca, K, P, Fe) and hence increased yield.

Likewise, the use of manure compost for poultry at 3 t ha^{-1} resulted in significantly larger increases in the field's height, dry weight, and total seed yield than the control [6]. Similar characteristics were obtained in faba bean research, during plants on compost, compost tea, and vermicompost tea applications, plant growth and yield increased significantly. The increase in branch number and plant height, and the improvement of fresh weight were remarkably attributed to vermicompost tea treatment [7].

The addition of poultry manure at 5 t ha^{-1} in *V. faba* (Barcelona variety) also enhanced plant height, number of branches, dry matter, and chlorophyll content [8, 9]. Furthermore, the application of poultry and cow manure and granular humus raised the levels of pod yield (as well as plant height, leaf area, pod number, and pod weight) over control treatments [10]. Organic fertilization was also reported to enhance phenotypes of faba bean types for local, French, and Turkish plants. Compared to the untreated plants, plants treated with organic fertilizers showed higher seed weight per pod (WMP), green seed yield (GSE), leaf area (LA), and pod length and weight [11].

On application method, soil drenching of compost tea was superior to foliar spraying, and it increased both leaf number and yield significantly, as well as seed weight and pod number (GSE) significantly, while boosting soil fertility and disease resistance [12]. Likewise, the Nubaria 1 and Nubaria 2 varieties showed beneficial growth and yield parameters with compost and compost tea applications [13].

Although compost tea is established to have positive effects on the performance of faba bean, research studies on the application strategy and concentration of buffalo manure compost tea have not been done yet. This indicates that this research will be conducted to examine the influence of different application methods (soil drenching vs. foliar spray) and concentrations (0-, 100-, and 200-mL L^{-1}) of buffalo manure compost tea on the growth, physiological, and yield characteristics of the Luz de Otoño faba bean variety.

MATERIALS AND METHODS

Site of Experiment and Design

The test was undertaken during the winter period of 2023-2024 at the Agricultural Research Station at the College of Agriculture, University of Basrah, Iraq. The aim was to examine the effect of applying an extract from organic (buffalo manure compost tea) fertilizer on the growth and yield of the Luz de Otoño broad bean (*V. faba* L.) cultivar. A factorial experiment plan was performed with a randomized complete block design (RCBD) in 3 replicates. On the one hand, the strategy applied was divided into two stages: soil drenching (irrigation) and foliar spraying. The second factor was the compost tea level, divided into three levels: 0 (control), 100-, and 200-mL L^{-1}. The experimental field was prepared by plowing, leveling, and dividing into three ridges, 15 m in length, 75 cm apart. Seeds were sown by hand, with each hole containing three seeds. Following germination, seedlings were thinned (one plant per hill) and evenly spaced. The length of each experimental plot was 2.5 m. Hoeing, weeding, thinning, fertilization, pest management, and harvesting were implemented as necessary following agronomical methods [14]. Throughout the growing process, drip irrigation was used. Preparation of Buffalo Manure Compost Tea. Compost tea was fermented in 180 liters of water on October 13, 2023, with 40 kg of buffalo manure. For the fermentation to initiate, urea fertilizer was added to the fermented mass to generate microbial activity. It was then aerated continuously for a period of two months to obtain adequate fermentation. Two concentrations were added after the fermentation period:

• 100 mL L^{-1}: by diluting 100 mL compost tea with distilled water to 1 liter.

• 200 mL L^{-1}: from 200 mL compost tea diluted with distilled water to 1 liter.

Compost tea treatments were given three times in the early morning at 40 days after planting, followed by the second and third times in two-week periods. Data Collection. Chemical traits were measured from representative plants in each plot. Chemical parameters were determined by selecting the fourth leaf from the apical growing tip following the procedure given by Watson and Watson [15]. The content of leaf carotene was assessed based on the methods presented by Zaehringer et al. [16], while the total soluble solids (TSS) were measured via an electronic refractometer. Vegetative growth indices included plant height (cm), number of branches per plant, number of leaves, leaf area (cm²), and fresh and dry weight of the shoot system. The leaf area was measured using the leaf-weight method reported by Watson (1958) [17]. Yield Components. Pod length (cm), pod weight (g), and seed dry matter percentage were yield traits. The pod size was kept in an oven at 70 °C at constant weight, and measurements were made using an analytical balance. Statistical Analysis. Statistical analyses were performed for all the data according to the factorial RCBD structure with support from the GenStat software package (VSN International, 2009). The Least Significant Difference (LSD) test was used to compare treatment means at the 0.05 probability level to determine significant differences between treatments [18].

Experimental Site and Design

The experiment was carried out during the winter period of 2023–2024 in the Agricultural Research Station belonging to the College of Agriculture, University of Basrah, Iraq. The aim was to study the impact of adding an extract from the organic fertilizer (buffalo manure compost tea) on the growth and yield of the Luz de Otoño broad bean (*V. faba* L.) cultivar. A randomized complete block design (RCBD) with three replications was planned as a factorial experiment. The first factor was the approach used, which was the application mode, consisting of both soil drenching (irrigation) and foliar spraying. The second factor was the compost tea levels: 0 (control), 100-, and 200-mL L^{-1}. The experiment ground was prepared by means of plowing, leveling, and spreading out into three ridges, 15 m long and 75 cm apart. Three seeds were sown in each hole. After germination, seedlings were thinned to one plant per hill, keeping the spacing uniform. Each plot was 2.5 m long to measure the experimental plots. As needed, standard agronomic practices, including hoeing, weeding, thinning, fertilization, pest control, and harvesting, had been carried out [14]. The complete growing period was cultivated using drip irrigation.

Preparation of Buffalo Manure Compost Tea

Compost tea was prepared by fermenting 40 kg of buffalo manure in 180 liters of water on October 13, 2023. At the start of the fermentation process, 25 g of urea fertilizer was incorporated to stimulate microbial activity. The mixture was continuously aerated and stirred for two months to ensure proper fermentation. Two concentrations were made after the fermentation:
• 100 mL L^{-1}: by diluting 100 mL of compost tea with distilled water to one liter.
• 200 mL L^{-1}: by diluting 200 mL of compost tea with distilled water to one liter.

Chemical Traits

Compost tea was applied three times in the early morning: the first time at 40 days after planting and then at two-week intervals thereafter. Chemical parameters (Table 1 and Table 2) were determined from representative plants from each plot. In accordance with Goodwin (1976), leaf chlorophyll content was determined as follows through the selection of the fourth leaf from the apical growing tip according to the method carried out for Watson and Watson [15]. Leaf carotene content, determined according to Zaehringer et al. [16], and total soluble solids (TSS) were determined using an electronic refractometer.

Vegetative Growth Parameters

Vegetative growth variables were the height (cm) of the plant, number of branches, leaves, area under leaf (cm²), and fresh and dry weight of the shoot system. The leaf area was determined by the leaf-weight method as defined by Watson (1958) [17].

Yield Components

Yield characteristics were podding length (cm), pod weight (g), and seed dry matter percentage. Pods were oven-dried at 70 °C until the weight was held constant and weighed, and analysis was performed in an analytical balance.

Statistical Analysis

Data were analyzed using statistical analysis based on the factorial data structure in RCBD by the factorial RCBD process for statistics by the GenStat software package (VSN International, 2009). Means of treatment were compared using the Least Significant Difference (LSD) test at the 0.05 probability level to confirm significant differences among treatments.

Table 1 Some of the physical and chemical characteristics of field soil in 2023

Soil properties		Units/measurement	Method reference
EC (dSm m^2)		7.39	(Page *et al.*, 1982)
PH		7.41	
Total nitrogen g. Kg^{-1}		24.7	
Organic matter (%)		1.06	
Available N	mg. Kg^{-1}	1.96	Page *et al.*, (1982)
Available P		25.7	
Available K		21.7	
Available Na		38.4	
Soil particles (%)	Sand	76.64	Black (1965)
	Silt	7.8	
	Clay	15.56	
	Texture	Sand clay	

Table 2 some of the main components of the organic compost extract (buffalo manure)

E.C.	3.76 mS/cm
pH	6.86
N	12.5 %
P	32 %
K	0.5 %

Organic matter	58.61%

RESULTS AND DISCUSSION

Table 3 shows that the effect of the addition method and concentrations made a noteworthy impact on the two traits, plant height and number of branches, while the interaction had no significant effect. Plant height and branch count increased significantly as a result of the irrigation addition strategy of 15.13% and 23.69%, respectively, compared to the foliar spray method. The same table's results reveal that for each of the qualities under investigation, the addition concentrations have a noteworthy impact that grows with increasing concentration. The concentration (200 ml L-1) caused a notable rise in comparison to the control and the concentration (100 ml L-1), by an increase rate of (32.94%, 18.12%, 85.28% and 32.11%, for the plant's height and the number of its branches, respectively.

Based on the results, the method and concentration of additive application significantly influenced plant growth, while their interaction did not. The irrigation addition method was superior to foliar spraying, enhancing plant height and branch number by 15.13% and 23.69%, respectively. Furthermore, a strong positive dose-response was evident, as the highest concentration (200 ml L^{-1}) elicited the greatest increases in both traits compared to the control and the lower (100 ml L^{-1}) concentration. This demonstrates that delivering the additive via irrigation at a high concentration is most effective for promoting vegetative growth, specifically plant height and branching. These findings align with established principles of plant nutrition, where the application method and optimal dosage are critical for maximizing physiological responses and yield potential [19].

Table 3 Effect of application method and concentration of compost tea (buffalo manure) on plant height and number of branches of green broad bean (*V. faba* L.).

Treatment	Plant height (cm ± SE)	No. of branches (± SE)
Soil drenching	50.22 ± 2.30	5.22 ± 0.38
Foliar spray	43.62 ± 3.13	4.22 ± 0.24
LSD (0.05)	1.99	0.48
0 mL L^-1	42.50 ± 0.29	3.33 ± 0.23
100 mL L^-1	47.83 ± 0.31	4.67 ± 0.26
200 mL L^-1	56.50 ± 0.32	6.17 ± 0.44
LSD (0.05)	2.44	0.59
Drenching × 0	44.33 ± 3.25	3.67 ± 0.83
Drenching × 100	52.00 ± 4.26	5.33 ± 0.92
Drenching × 200	54.33 ± 4.26	6.67 ± 1.10
Foliar × 0	40.67 ± 5.29	3.00 ± 0.85
Foliar × 100	43.67 ± 4.25	4.00 ± 0.90
Foliar × 200	46.67 ± 3.29	5.67 ± 0.94
LSD (0.05)	NS	NS

NS= Not significant at P≤ 0.05. LSD= Least Significant Difference.

The findings in Table 4 indicate the ground's substantial impact addition method and high concentrations of compost tea, as the method of addition by the vegetative group's leaf area, Dry weight and leaf count both dramatically increased as a result of watering with an increase percentage of (53.87 and 71.57) % compared to foliar spraying, respectively, while the addition method had no discernible impact on the plant's fresh weight. The same table shows that the addition concentrations (100 and 200 ml L-1) brought about a notable rise in the fresh weight of the plant with an increase of (27.30 and 26.23)% in contrast to the comparative therapy, in turn, with an increase of (61.58 and 146.26)% for the leaf area, respectively with an increase percentage of (81.31 and 153.84)% within the total number of leaves, in proportion to a rise in the vegetative group's dry weight percentage of (41.31 and 51.77)% compared to the comparison treatment. The two factors had a significant effect on all traits except for the dry weight of the vegetative group, which increased significantly in the ground application treatment at a focus of (200 ml L^{-1}), producing a greater dry weight the plant (51.75 g) compared to (31.1 g) in the untreated control.

Based on the results, the application method and concentration of compost tea significantly influenced vegetative growth, while their interaction was only significant for dry weight. Soil drenching proved superior to foliar spraying, markedly enhancing leaf area and dry weight by 53.87% and 71.57%, respectively. Furthermore, both concentrations (100 and 200 ml L^{-1}) significantly increased all measured traits compared to the control, with the higher concentration generally yielding the greatest improvement. The most pronounced effect was observed in the combination of soil drenching and the 200 ml L^{-1} concentration, which produced the highest dry weight. This underscores that soil application of concentrated compost tea is highly effective for promoting robust vegetative growth, likely by enhancing nutrient availability to the root system [20].

Table 4 Effect of application method and concentration of compost tea (buffalo manure) on shoot dry weight, fresh weight, leaf area, and number of leaves of green faba bean plants (*V. faba* L.).

Treatment	No. of leaves (plant^{-1}± SE)	Shoot dry weight (g ± SE)	Shoot fresh weight (g ± SE)	Leaf area (cm² ± SE)
Application method				
Soil drenching	102.6 ± 8.19	43.03 ± 2.35	238.4 ± 10.97	22.22 ± 1.18
Foliar spray	59.8 ± 6.21	41.19 ± 3.28	227.8 ± 9.24	14.44 ± 1.11
LSD (0.05)	20.3	1.41	NS	3.52
Compost tea concentration (mL L^{-1})				
0	45.5 ± 6.14	32.14 ± 2.89	197.8 ± 10.28	10.83 ± 0.98
100	82.5 ± 8.21	45.42 ± 4.10	251.8 ± 12.59	17.50 ± 1.63
200	115.5 ± 10.13	48.78 ± 4.39	249.7 ± 12.51	26.67 ± 2.40

LSD (0.05)	24.9	1.73	16.21	4.31
Interaction (Application × Concentration)				
Soil drenching × 0	54.0 ± 6.48	31.10 ± 3.73	198.3 ± 23.79	14.67 ± 1.76
Soil drenching × 100	106.3 ± 12.76	46.20 ± 5.55	253.7 ± 30.45	21.00 ± 2.52
Soil drenching × 200	147.3 ± 19.15	51.75 ± 6.24	263.3 ± 31.60	31.00 ± 3.42
Foliar spray × 0	37.0 ± 4.07	33.17 ± 3.87	197.3 ± 23.66	7.00 ± 0.65
Foliar spray × 100	58.7 ±7.00	44.60 ± 5.42	250.0 ± 30.61	14.00 ± 1.27
Foliar spray × 200	83.3 ± 10.00	45.81 ± 5.50	236.0 ± 28.33	22.33 ± 2.09
LSD (0.05)	NS	2.45	NS	NS

NS= Not significant at P≤ 0.05. LSD= Least Significant Difference.

The results indicate that the methods of treatment significantly affected certain components of the crop under study, with the exception of pod length (see Table 5). Fertilization via irrigation proved to be significantly more effective than spraying for increasing seed content of total soluble solids, pod weight, and the percentage of dry matter in seeds, showing increases of 14.56%, 81.70%, and 7.04%, respectively. This increase may be attributed to the application of compost through irrigation, which improved soil acidity and stimulated the plant's ability to absorb water and nutrients. As a result, photosynthesis became more efficient, leading to greater productivity and accumulation of nutrients in the seeds. Additionally, the data from the table suggests that different concentrations of compost tea resulted in a significant enhancement of all characteristics studied, with improvements correlating to the concentration used. For instance, a compost tea concentration of 200 ml L-1 demonstrated significant superiority compared to the control and the 100 ml L-1 concentration, resulting in increases of 36.36% and 12.61% in total soluble solids, 70.99% and 36.19% in the percentage of dry matter in seeds, 46.15% and 12.89% in pod length, and 77.14% and 30.12% in pod weight, respectively. The notable enhancements in these characteristics can be attributed to the active components found in the compost tea, which provide essential major and minor nutrients that promote vegetative growth and the accumulation of manufactured nutrients, facilitating their transfer to the seeds. This ultimately results in an improvement in both the quantitative and qualitative yield. Furthermore, the interaction of irrigation with compost tea at a concentration of 200 ml L-1 yielded the highest values for pod length and pod weight, measuring 19.33 cm and 25.67 g, respectively. In contrast, untreated plants recorded the lowest values, with pod length at 12.33 cm and pod weight at 9.27 g.

Based on the results, both the application method and concentration of compost tea significantly enhanced key yield components. Soil drenching outperformed foliar spraying, substantially increasing pod weight, total soluble solids, and seed dry matter. This superiority is likely due to improved soil conditions and enhanced nutrient uptake, leading to more efficient photosynthesis and assimilate partitioning to the seeds. Furthermore, a strong positive dose-response was observed, with the 200 ml L^{-1} concentration yielding the greatest improvements in all pod and seed quality parameters. The significant interaction for pod length and weight, where soil drenching at 200 ml L^{-1} produced the highest values, confirms that this combined approach is optimal for maximizing crop yield and quality through improved plant nutrition [21].

Table 5 Effect of application method and concentration of compost tea (buffalo manure) on quantitative and qualitative yield components of green faba bean (*V. faba* L.).

Treatment	T.S.S. (%)	Dry matter in seeds (%)	Pod length (cm)	Pod weight (g)
Application method				
Soil drenching	7.00 ± 0.66	13.07 ± 1.18	16.67 ± 1.28	19.04 ± 1.85
Foliar spray	6.11 ± 0.55	12.21 ± 1.10	15.89 ± 1.78	16.04 ± 1.36
LSD (0.05)	0.41	0.80	NS	1.03
Compost tea concentration (mL L^{-1})				
0	5.50 ± 0.50	9.31 ± 1.84	13.00 ± 1.36	12.73 ± 1.79
100	6.66 ± 0.61	12.68 ± 1.22	16.83 ±1.58	17.33 ± 1.27
200	7.50 ± 0.68	15.92 ± 1.18	19.00 ± 1.98	22.55 ± 1.98
LSD (0.05)	0.51	0.99	1.45	1.27
Interaction (Application × Concentration)				
Soil drenching × 0	6.00 ± 0.56	9.27 ± 1.89	12.33 ± 1.58	12.02 ± 1.57
Soil drenching × 100	7.33 ± 0.67	13.09 ± 1.78	18.33 ± 1.94	19.42 ± 1.74
Soil drenching × 200	7.66 ± 0.69	16.84 ± 1.98	19.33 ± 1.58	25.67 ± 1.45
Foliar spray × 0	5.00 ± 0.49	9.36 ± 1.65	13.67 ± 1.57	13.43 ± 1.42
Foliar spray × 100	6.00 ± 0.56	12.26 ± 1.75	15.33 ± 1.73	15.24 ± 1.38
Foliar spray × 200	7.33 ± 0.69	15.01 ± 1.69	18.67 ± 1.69	19.43 ± 1.68
LSD (0.05)	NS	NS	2.05	1.79

NS= Not significant at P≤ 0.05. LSD= Least Significant Difference.

Additionally, the findings demonstrated that the amount of chlorophyll in the leaves and carotene pigments showed a higher increase when treated with the irrigation method, as the leaf content of chlorophyll increased significantly by 13.73% compared to the foliar spray, while the application method did not show a clear effect on the amount of carotene in leaf pigments (Table 6). In general, increasing the concentration of compost tea always caused the plant content to rise noticeably. Of the two pigments, as the concentration (200, 100 ml L-1) led to a notable rise in the amount of chlorophyll in the leaves by (19.89, 16.90) % and a notable rise in the number of leaves by (88.8, 28.0) % compared to the control treatment. The interaction by irrigation method at a concentration of (200 ml L-1) showed the highest chlorophyll content in the leaves, reaching (7.02 mg 100 fresh weight) compared to (4.95 mg fresh weight) in the unsprayed plants, while the interaction effect on the leaf content of carotene pigment did not appear.

Based on the results, the application method and concentration of compost tea significantly influenced pigment content. Soil drenching significantly enhanced chlorophyll concentration by 13.73% compared to foliar spray, though it did not affect carotene. Furthermore, a clear positive dose-response was observed, with both compost tea concentrations (100 and 200 ml L^{-1}) significantly increasing chlorophyll and carotene levels relative to the control, with the higher concentration being most effective. The significant interaction for chlorophyll, where soil drenching at 200 ml L^{-1} yielded the highest value (7.02 mg/100g FW), demonstrates that this combined treatment is optimal for maximizing photosynthetic capacity. This enhancement is likely due to improved nutrient availability, particularly nitrogen and magnesium, which are essential for chlorophyll synthesis [19].

Table 6 Effect of application method and concentrations of compost tea on leaf content of photosynthetic pigments in green fava beans

Treatments	Leaf chlorophyll (mg 100 g^{-1} FW)	Leaf carotene (mg 100 g^{-1} FW)
Application method		
Drenching	6.79 ± 0.61	0.0179 ± 0.002
Foliar spray	5.97 ± 0.54	0.0167 ± 0.001
$LSD_{0.05}$	0.21	NS
Compost tea (ml L^{-1})		
0	5.68 ± 0.51	0.0125 ± 0.001
100	6.64 ± 0.60	0.0160 ± 0.001
200	6.81 ± 0.64	0.0236 ± 0.002
$LSD_{0.05}$	0.26	0.0039
Interaction (Application × Concentration)		
Drenching × 0	6.41 ± 0.77	0.0126 ± 0.002
Drenching × 100	6.93 ± 0.83	0.0160 ± 0.003
Drenching × 200	7.02 ± 0.84	0.0236 ± 0.003
Foliar spray × 0	4.95 ± 0.59	0.0123 ± 0.002
Foliar spray × 100	6.36 ± 0.76	0.0143 ± 0.002
Foliar spray × 200	6.59 ± 0.79	0.0235 ± 0.004
$LSD_{0.05}$	0.37	NS

NS= Not significant at P≤ 0.05. LSD= Least Significant Difference.

CONCLUSION

The findings in this study clearly show that the Luz de Otoño green broad bean (*V. faba* L.) developed successful growth and improved its growth and yield under the Basra environment (Garmet Ali) when buffalo manure compost tea is used in such a growing ground, particularly in order to boost its efficiency and productivity. Soil application had optimal effects on growth, physiological, and yield characteristics of crops with drenching of 200 mL L^{-1} buffalo compost tea to improve the yield of the crop over all tested treatments. These treatments exhibited the highest increase in utilization as far as growth. In response, application of buffalo compost tea should be done three times over the growing season, typically during the first 40 days following the planting, and then two additional times at two-week intervals. Because it increases crop yields, reduces fertilization inputs, and improves soil fertility, microbial activity, and nutritional resources, this method not only improves plant yield but supports more sustainable agricultural development. Owing to the environmental sustainability of buffalo-based organic liquid fertilizers, it is advantageous, given the widespread popularity of synthetic fertilizers. Longitudinal studies should investigate the influences that repeated use of compost tea can have on soil health, nutrient cycling, and crop quality in different environmental conditions and legume cultivars.

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