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Using powdered fallen leaves as organic fertilizer (plant compost) as an alternative to chemical fertilizers

[*]Embarek, A. F. B., **Mumin S. I. J. and ***Jummah,W. A.

[*] Faculty of Natural Resources and Environmental Sciences- University of Tobruk
[**]Faculty of Natural Resources and Environmental Sciences- University of Derna
[*] Faculty of Sciences- University of Tobruk

amani.badr@tu.edu.ly

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ABSTRACT

A pots experiment was conducted in the city of Tobruk during the 2024/2025 season, where fallen green leaves from trees were collected from multiple places, cleaned, then ground into a fine powder and mixed with the soil before planting the bean plant (*Vicia faba*), El-Kobrosy cultivar. The treatments were arranged in a design Randomized complete block (RCBD), with three replicates. The studied traits included vegetative traits (plant height, total fresh weight, number of branches/ plant, average leaf area, total chlorophyll), yield traits (number of pods/ plant, number of seeds/ pod, pod weight, weight of 100 seeds), chemical content (nitrogen, phosphorus, potassium, protein, total carbohydrates). The results showed that increasing the rate of adding green manure powder to the soil, 300g/2 kg of soil, led to a significant increase in all vegetative traits (plant height, total fresh weight, number of branches/plant, average leaf area, total chlorophyll) and crop traits (number of pods/plant). Number of seeds/pod, weight of pod, weight of 100 seeds), chemical content (nitrogen, phosphorus, potassium, protein, total carbohydrates), followed by the rate of adding green manure powder to the soil, 200 g/ 2kg of soil, compared with the control treatment (without addition), which recorded the lowest values for all the studied traits. We conclude from the previous results that the powder of ground green leaves (green manure) proved effective on all the studied traits due to its positive effect on the physical and chemical properties of the soil, and this was reflected in recording the highest moral values for all the studied traits, while the positive control outperformed the negative control, recording relatively higher values.

Keywords: Faba bean- green manure-vegetative traits- yield traits- chemical content

INTRODUCTION

Faba bean (*Vicia faba*) is a rich source of minerals and nutrients **(Khursheed *et al.*, 2018)** and many biologically active secondary metabolites **(Mekky *et al.*, 2020),** it is a cheap source of protein **(Mulugeta *et al.*, 2021).** Faba bean is a preferred yield due to their good taste and environmental value in sustainable agricultural systems **(Uçar *et al.*, 2021).** The protein content in faba beans is higher than that of other legumes. This yield is primarily produced for its dry seeds, but its pods or fresh seeds are also used as vegetables in many countries. Faba bean sprouts are also part of the human diet. The dried or fresh branches and leaves of this type are considered good fodder for cattle and sheep. Diverse practices of bean cultivation, such as interyieldping and rotation, are well-adopted in agricultural systems around the world **(Zong *et al.*, 2019).**

Broad bean is an important legume yield grown in winter and has the ability to be cultivated as a multipurpose yield in areas with short growing seasons **(Etemadi *et al.*, 2019)**

Faba beans have high nutritional value due to their high content of carbohydrates (42-47%), protein (up to 35% in dry seeds), and various types of minerals (K, Ca, Mg, Fe, Zn), as well as bioactive compounds **(Karkanis *et al.,* 2018)**. Cultivating faba bean in any agricultural system can enhance soil fertility and biological activity due to their symbiotic relationship with rhizobium bacteria, which increases biological nitrogen fixation can fix nitrogen up to 200 kg/ha **(Neugschwandtner *et al.,* 2015),** while mixing its residues with the soil can improve soil porosity, bulk density, organic matter, and water retention capacity **(Nebiyu *et al.,* 2014).** Therefore, industrial fertilizers have become a risk to human and animal health, leading to environmental degradation and the destruction of microbial biodiversity **(Adekiya *et al.,* 2019; Bisht and Chauhan 2020).** To mitigate the negative impacts of industrial fertilizers on the environment and human health and to achieve sustainability in agriculture, modern agricultural initiatives have been taken to reduce the use of industrial fertilizers and replace them with other organic amendments such as organic fertilizers and biofertilizers. Organic and biological fertilizers not only provide essential nutrients for plants but also maintain soil health for subsequent yields **(Lin *et al.,* 2019).**

Chemical fertilizers are the main source of nutrients and for maintaining soil fertility worldwide. Due to the high cost of chemical fertilizers and environmental concerns, the development of more economical and environmentally friendly alternatives is necessary **(Loh *et al.,* 2019).**

The use of green manure in yield production has been identified as a viable and environmentally acceptable economic approach as an alternative to chemical pesticides, which can enhance soil health, plant productivity, and their resilience to biotic and abiotic stresses **(Chimouriya *et al.,* 2018).** Green manure provides significant benefits to the soil, including increased organic matter and nutrients, improved soil structure, and enhanced weed control **(Suon *et al.,* 2023).** Among the agricultural practices that have been widely explored, organic fertilizers have garnered increasing attention as a potential source of safer nutrients to ensure agricultural sustainability and the production of fruits and vegetables with high nutritional value **(Ramos-Agüero and Terry-Alfonso, 2014).** However, due to intensive production and the transformation of agricultural systems, green manure areas have gradually declined over the past decades **(Lei *et al.,* 2022).** In fact, chemical fertilizers have gradually become the main source of nutrients for agriculture **(Huang and Zou, 2020),** and the long-term use of these agricultural chemical inputs has led to significant decreases in soil fertility and changes in soil quality, among other things, thru acidity and the accumulation of heavy metals **(Li *et al.,* 2020).** In recent years, soil health has regained significant attention from both researchers and farmers who aim to reduce the use of synthetic fertilizers and other agricultural chemical inputs due to their harmful effects on human health and environmental risks. In fact, soil biology support is essential for the sustainability and resilience of agricultural production **(Ghorbi *et al.,* 2023).**

According to the study by **Lei *et al.* (2022),** the application of green manure significantly enhanced the structure of the microbial community in the soil, biomass, and diversity, leading to increased nutrient absorption and utilization by plants. The introduction of plant residues from green manure yields into the soil can enhance the sustainability of the agricultural system by improving the physical and biological properties of the soil and reducing root and leaf-related diseases. The relationship between carbon in microbial biomass and microbial enzyme activity per unit area of soil microorganisms indicates the number and activity of enzymes capable of decomposing green manure **(Yanyu *et al.,* 2019).**

The decomposition process is faster when plant residues are incorporated into the soil compared to when they are left on the soil surface **(Stagnari and Pisante, 2010).** Green manure yields include legumes, which can fix atmospheric nitrogen thanks to the root-associated bacteria, and non-legumes. They form an excellent source of nutrients for economically important agricultural yields and are also capable of improving soil fertility and productivity.

Several studies have shown that incorporating legume residues into the soil as a green manure preceding main yields leads to significant increases in growth and productivity parameters in many yields such as canola **(O'Donovan *et al.*, 2014),** corn **(Bilalis *et al.*, 2012),** potatoes **(Sincik *et al.*, 2008),** and wheat **(Miller *et al.*, 2011).**

The objective of the research:

Utilizing plant residues and converting them into organic fertilizers, which reduces the consumption of mineral fertilizers harmful to the environment, soil, and human health.

Materials and Methods:

A pot experiment was conducted in the city of Tobruk during the 2024/2025 season, where fallen green leaves from fig and olive trees were collected from various locations, cleaned, ground into a fine powder, and then stored until the experiment was conducted. 20 cm diameter pots were prepared and filled with 2 kg of soil, and the soil was mixed with the ground green manure at different rates (negative control, positive control, 100, 200, 250, 300 g). The treatments were arranged in a completely randomized block design (RCBD) with three replications.

Three seeds of the local faba bean variety El-Kobrosy were planted on November 15, 2024/2025 in each pot, under a drip irrigation system. The plants were thinned twice, the first time 15 days after planting and the second time two weeks after the first thinning. The control soil was mixed with calcium superphosphate (15.5%), potassium sulfate (48.5%), and nitrogen fertilizer in the form of urea (48% N) to enhance symbiotic bacteria and meet the nutritional needs in the early stage of the faba bean plants.

Table (1): Physical and chemical properties of soil

Parameter	Value	Unit
Mechanical Analysis		
Sand	7.26	%
Silt	12.52	%
Clay	80.23	%
Textural class	**Clay**	
pH (1:1)	8.7	-
$CaCO_3$	16.51	%
EC(1:1, water extract)	280	dS/m
O.M	1.08	%
Na^+	45	%
Nitrogen (N)	17.1	mg/kg
Phosphorus (P)	28.1	mg/kg
Potassium (K)	48.4	mg/kg

Studied Characteristics:

A) Vegetative characteristics:

- **Plant height (cm):** measured from the soil surface to the top of the plant **(Jose and Paterniani, 2002).**
- **Total fresh weight of the vegetative parts** (leaves and stems) (g), plants were weighed directly from each experimental unit **(Radwan and Al-Fakhri, 1976).**
- **Total dry weight of the vegetative parts (g):** the vegetative parts were dried and then weighed **(Radwan and Al-Fakhri, 1976).**
- **Number of leaves/plant:** the total number of leaves from each experimental unit was calculated and averaged **(Ramakrishnan *et al.*, 2013).**
- **Leaf area (cm^2):** Maximum length × maximum width **(Sakar *et al.*, 2003).**

- **Total chlorophyll (SPAD):** The chlorophyll content in fresh leaves was measured using a chlorophyll meter (Minolta SPAD-502, Tokyo, Japan). The values were measured as SPAD.

B) Yield characteristics: At the end of the physiological maturity stage, the yield and its components were measured as follows:

- Number of pods/plant
- Pod length (cm)
- Pod weight (g)
- Number of seeds/pod
- Weight of 100 seeds

C) Chemical content:

The percentage of nitrogen, phosphorus, and potassium (NPK) in the dried leaves was determined. Their dry weights were determined after drying in a drying oven to a constant weight at 70°C for 72 hours according to **(Tandon, 1995).** After drying, plant samples were ground and stored for analysis. 0.5 g of the leaf powder was digested with an H_2SO_4–H_2O_2 mixture, and the NPK was measured in the digestion solution **(Lowther, 1980).**

- **Nitrogen (N):**

The percentage of nitrogen in digested leaves was estimated using the Nessler method **(Chapman and Pratt, 1978).** The Nessler solution consisted of 35 g potassium iodide/100 mL distilled water + 20 g mercuric chloride/500 ml distilled water + 120 g sodium hydroxide/250 ml distilled water). Readings were taken using a wavelength of 420 nm, and N was determined as a percentage as follows:

% N = % NH4 x 0.776485

- **Phosphorus (P):**

Phosphorus was estimated using the Vanadomolyate Yellow method, and the color intensity was read using a spectrophotometer at 405 nm.

- **Potassium (K):**

Potassium was estimated using a Beckman Flame photometer.
Phosphorus and potassium were estimated according to **Jackson (1973).**

- **Statistical analysis**

Data were analyzed using the Statistical Analysis Service **(SAS, 2008).** Duncan's multiple range tests were used at a significance level of 5% to compare the treatments according to **Gomez and Gomez, (1984).**

RESULTS AND DISCUSSION

A) Vegetative characteristics:

The results shown in **Table (1) and Fig. (1)** indicated that the application of green manure had a significant effect on the studied vegetative characteristics (plant height, fresh weight, dry weight, number of branches/plant, average leaf area, and total chlorophyll) of faba bean cv. "El-Kobrosy". The results showed that increasing the application rate of green manure to 300 g/2 kg of soil increased the average values of the following vegetative characteristics: plant height (96.95 cm), fresh weight (568.05 g), dry weight (126.23 g), number of branches/plant (4.49), leaf area (2.92 cm^2) and total chlorophyll (43.92). This was followed by a rate of 250 g/2 kg of soil, where the plant height recorded was (92.75 cm), fresh weight (548.45 g), dry weight (126.88 g), number of branches/plant (3.47), leaf area (2.60 cm^2) and total chlorophyll (39.34 SPAD), as compared to the negative control treatment which recorded the lowest values for plant height (53.12 cm), total fresh weight (263.47 g), total dry weight (58.55 g), number of branches/plant (2.24), average leaf area (1.69 cm^2), total chlorophyll (25.53 SPAD), while the positive control outperformed the negative control as it recorded relatively higher values for plant height (67.20 cm), total fresh weight (395.85 g), total dry weight (87.97 g), number of branches/plant (2.64), leaf area (1.98 cm^2), total chlorophyll (30.04 SPAD), respectively.

The increase in plant height may be due to the effect of organic fertilizer, which properly develops the soil, thus providing water and macro- and micronutrients to the aerial environment around the root zone, supplementing the mineral fertilizers that nourish the plants. The effect of biofertilizers, which address all absorption and adsorption issues, supports the interaction of the three elements involved in application. These results are consistent with those reported by **El-Shamy *et al.* (2015); Amini *et al.* (2016); Rasul (2017).** The increase in total chlorophyll content in beans may be due to increased nitrogen uptake from organic and biological fertilizers, which may stimulate the production of plant hormones that activate photosynthesis and chlorophyll levels. In this regard, **Awan and Baloch (1999)** reported a positive relationship between chlorophyll and nitrogen content in plants. Consequently, plant growth may be enhanced. Chlorophyll content shows a direct response to nitrogen and phosphorus in plant leaves, and studies have shown that organic fertilizers are rich sources of nitrogen, phosphorus, potassium and other micronutrients **(Krishnasamy *et al.*, 2012; Chiew *et al.*, 2015),** which can promote growth and chlorophyll content in beans.

Table (1): Effect of green manure rates (dry leaf powder) on the vegetative characteristics of faba bean plants during 2024/2025 season.

Treatments	Plant height (cm)	Total fresh weight (g)	Total dry weight (g)	No. of branches / plant	Leaf area (cm^2)	Total chlorophyll (SPAD)
Green manure levels (g)						
Negative control	53.12	263.47	58.55	2.24	1.69	25.53
Positive control	67.20	395.85	87.97	2.64	1.98	30.04
100	81.55	458.50	101.89	2.73	2.22	33.56
200	88.82	475.30	105.62	3.26	2.48	36.57
250	92.75	548.45	121.88	3.47	2.60	39.34
300	96.95	568.05	126.23	4.49	2.92	43.92
$LSD_{(0.05)}$	**4.79**	**46.56**	**10.35**	**1.40**	**0.29**	**5.05**

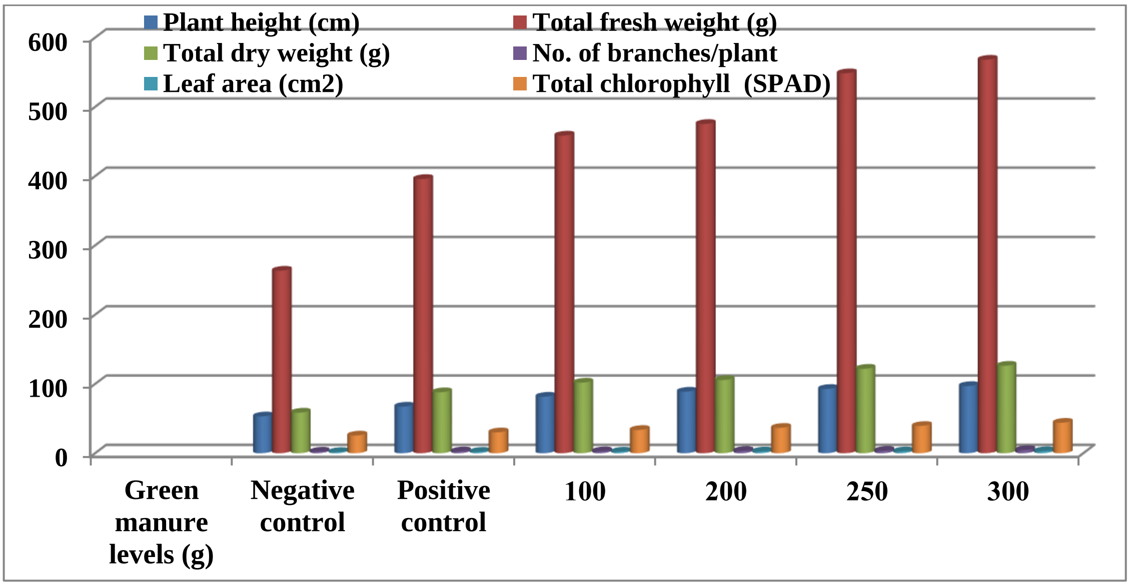

Fig. (1): Effect of green manure rates (dry leaf powder) on the vegetative characteristics of faba bean plants during 2024/2025 season.

B) Yield characteristics

The results shown in **Table (2) and Fig. (2)** indicate that the application of green manure had a significant effect on the studied yield characteristics (number of pods/plant, number of seeds/pod, pod weight (g), pod length (cm), and weight of 100 seeds (g) for the broad bean variety El-Kobrosy. The results showed that increasing the application rate of green manure to 300 g/2 kg of soil led to an increase in the average values of the yield characteristics (number of pods/plant (24.70), number of seeds/pod (6.33), and pod weight (24.85) g), pod length (13.42 cm), and weight of 100 seeds (95.67) g). This was followed by an application rate of 250 g/2 kg of soil, which recorded (number of pods/plant (24.06), number of seeds/pod (5.00), pod weight (23.45) g, pod length (12.66 cm), and weight of 100 seeds (90.32 g), compared to the control treatment (without addition), which recorded the lowest values for the yield traits (number of pods/plant (16.00), number of seeds/pod (3.25), pod weight (14.84 g), pod length (8.01 cm), weight of 100 seeds (50.75 g), while the positive control outperformed the negative control, as it recorded relatively higher values for the number of pods/plant (19.00), number of seeds/pod (4.00), pod weight (18.55 g), pod length (10.02 cm), weight of 100 seeds (63.44) g), respectively.

Green manure significantly increased maize yields. It generally provides a biomass of readily mineralized organic matter, thus increasing biological activity **(La Voie agricole, 2004).** The contributions of biological and organic fertilizers complement expensive and environmentally damaging synthetic fertilizers. Cereals have always played a vital role in human life, and political economy has been born from concerns about the production and distribution of these foodstuffs **(Marsal, 1999). Mandal *et al.* (2003)** also noted the increased rice yields and successful wheat yields in Sespania with green manure. **Annabi *et al.* (2007)** stated that the amount of decomposed organic matter on the soil surface can also enhance infiltration. Soil organic matter can be increased by adding organic fertilizers such as green manure and animal manure. Regular use of green manure leads to a high reserve of organic matter, which enhances the chemical and physical properties of the soil. Furthermore, interyieldping green manure enhances nutrient recycling efficiency, as regular pruning strategies increase soil organic matter and other nutrients. The improved soil properties of cultivated land are reflected in increased yield yields **(Egodawatta *et al.*, 2011).**

Green manure has gained increasing attention in recent years due to its ability to enhance soil fertility, improve yield yields, and promote sustainable agricultural practices **(Cai *et al.*, 2019; Ma *et al.*, 2021).**

Table (2): Effect of green manure rates (dry leaf powder) on the yield characteristics of faba bean plants during 2024/2025 season.

Treatments	No. of pods / plant	No. of seeds / pod	Pod weight (g)	Pod length (cm)	100-seeds weight
Green manure levels (g)					
Negative control	16.00	3.25	14.84	8.01	50.75
Positive control	19.00	4.00	18.55	10.02	63.44
100	21.54	4.33	21.00	11.34	79.16
200	23.44	4.67	22.75	12.29	83.81
250	24.06	5.00	23.45	12.66	90.32
300	24.70	6.33	24.85	13.42	95.67
$LSD_{(0.05)}$	**3.83**	**1.48**	**2.25**	**1.22**	**8.36**

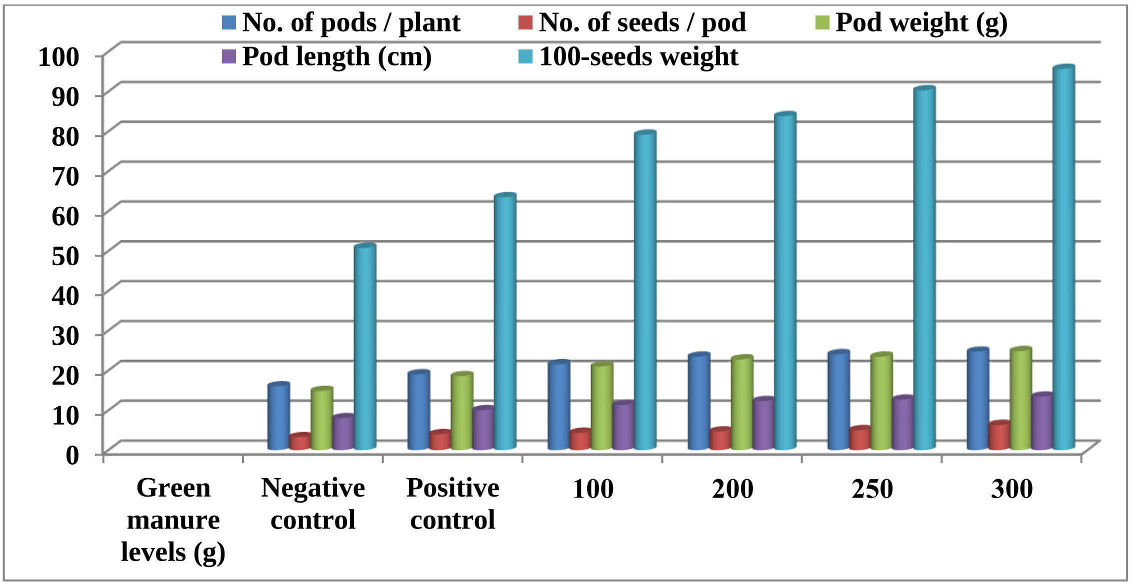

Fig. (2): Effect of green manure rates (dry leaf powder) on the yield characteristics of faba bean plants during 2024/2025 season.

C) Chemical composition

The results shown in **Table (3) and Fig. (3)** indicate that the addition of green manure had a significant effect on the studied chemical properties (nitrogen, phosphorus, potassium, protein, and total carbohydrates) of the broad bean variety El-Kobrosy. The results showed that increasing the application rate of green manure to 300 g/2 kg of soil resulted in the highest average values of the chemical properties: nitrogen (4.06%), phosphorus (0.49%), potassium (2.08%), protein (25.38%), and total carbohydrates (56.05%). This was followed by fertilization at a rate of 250 g/2 kg of soil, which resulted in nitrogen (3.64%), phosphorus (0.44%), potassium (2.03%), protein (22.75%), and total carbohydrates (51.61%). This was in comparison with the control treatment (no addition), which recorded the lowest values for nitrogen content (2.11%), phosphorus (0.21%), potassium (1.25%), protein (13.19%), and total carbohydrates (33.75%) were present in the soil, while the positive control outperformed the negative control, recording relatively higher values for nitrogen content (2.80%), phosphorus (0.36%), potassium (1.80%), protein (17.50%), and total carbohydrates (41.49%), respectively.

As soil amendments, green manure improves soil water retention, oxygen status, and organic carbon content, enabling abundant growth of microorganisms in the roots and soil. This, in turn, increases the availability of nutrients uptake by plant roots **(Marschner and Roemheld, 1996; Vinod Kumar *et al.*, 1999)**. Amino acids derived from soil protein hydrolysis can play a role in lowering pH and act as carriers of micronutrients, making them more available to plant roots **(Cakmak *et al.*, 1994).**

The decomposition of organic matter and the conversion of nutrients are enhanced with increased activity of soil microorganisms and their enzymes, thereby increasing the effectiveness of plant nutrient availability **(Yang *et al.*, 2014).**

Table (3): Effect of green manure rates (dry leaf powder) on the chemical composition of the faba bean plant during 2024/2025 season.

Treatments	N (%)	P (%)	K (%)	Protein (%)	Total carbohydrates (%)
Green manure levels (g)					
Negative control	2.11	0.21	1.25	13.19	33.75
Positive control	2.80	0.36	1.80	17.50	41.49
100	3.52	0.38	1.82	22.00	45.18
200	3.71	0.41	1.88	23.19	47.81
250	3.64	0.44	2.03	22.75	51.61
300	4.06	0.49	2.08	25.38	56.05
LSD$_{(0.05)}$	**0.16**	**0.02**	**0.06**	**0.98**	**5.07**

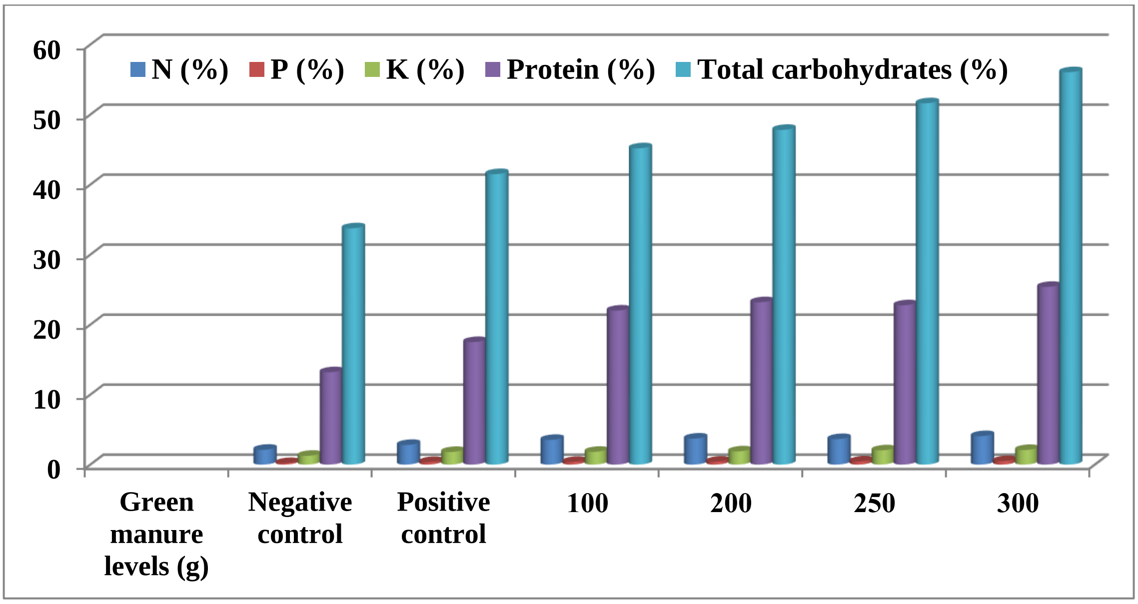

Fig. (3): Effect of green manure rates (dry leaf powder) on the chemical composition of the faba bean plant during 2024/2025 season.

Conclusions and Recommendations

- **Conclusions:**

We conclude from the preceding results that ground green leaf powder (green manure) proved effective on all studied traits due to its positive impact on the physical and chemical properties of the soil. This was reflected positively in the recording of the highest significant values for all studied traits.

- **Recommendations:**

In light of the positive results obtained from the experiment, we recommend the following:

- Expanding the use of green manure because it is inexpensive, pathogen-free, decomposes quickly, and is environmentally friendly.

- Gradually reducing the use of chemical fertilizers and replacing them with green manure due to its positive impact on human health and the improvement of the physical and chemical properties of the soil.
- Because it is a clean fertilizer free of weed seeds and pathogens, we recommend expanding its use due to its environmental friendliness.

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