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RESEARCH ARTICLE

Exploring different organic manures in the production of quality basil seedlings

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Abstract
In recent years, the demand of people for medicinal and aromatic plants has dramatically increased. For this reason, a large number of researches are being conducted to make these plants more quality. In this sense, this study explored the effects of domestic peat, bat guano, chicken and sheep manures, and vermicompost on the growth, quality traits, and nutrient contents of basil (*Ocimum basilicum* L.). For this purpose, an experiment in greenhouse conditions was arranged in a completely randomized design with four replications. The treatments included control (100% Peat/Perlite) and three doses (2%, 4%, 6%) for each of four organic manures. In total, there were 13 treatments. The study showed that there were significant differences among treatments for aesthetic appearance score, height, and fresh and dry weights of plants with the exception of crown width. Control and "94% Peat/Perlite + 6% Bat guano" had the lowest and highest values of all growth and quality traits. Overall, it concluded that "94% Peat/Perlite + 6% Bat guano" should be used in planting basil. Further studies including different organic manures and their combinations are required to obtain better growth and quality traits as well as physiological traits of basil.

Keywords Basil · Growing medium · Growth · Organic manure · Quality

Introduction

Human beings have met many of their needs such as nutrition, clothing, and shelter from plants since their existence. Increases in the population and living standards due to the technological advancements have raised the demand of people for plants (Alpaslan et al. 2015; Cetin et al. 2018; Yücedağ et al. 2019; Cetin and Jawed 2022). Therefore, the use of agricultural lands for different purposes has caused serious losses especially in the lands where plant activities can be done. On the other hand, plant activities, which dates back ancient times, have developed and shaped over time thanks to different techniques, methods, and applications. In addition to the planned and correct use of existing production areas, researches including new and useful techniques are essential in order to obtain more yields per unit area (Aksoy 2018).

Studies related to the growing media in Turkey started in the early 1970s and increasingly continued until today. In this process, perlite, tuff, and peat have been extensively studied as growing media. Although growing media is often desired to have all good characteristics, this is not always possible. Therefore, the physical properties of the growing media are primarily considered owing to their importance (Çiçek Atikmen and Kütük 2014; Cappelini et al. 2021; Çiçek Atikmen et al. 2018; Çiçek and Yücedağ 2021a, b; Cetin et al. 2022; Mustafa et al. 2022).

Peat is intensively used in landscape activities as well as in vegetable, ornamental plants, and mushroom cultivation in Turkey. In order to meet the demand of producers who realize the superior properties of peat, domestic commercial companies market the peat in open or packed form by extracting it from different peat beds in Turkey. Since the

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price of these local peats is lower than the imported peat, they are especially preferred by producers with low income. However, since some domestic peats are not as qualified and homogeneous as imported ones and lack the necessary physical and chemical additives, they lose the confidence of the producer over time (Çiçek Atikmen and Kütük 2014). Thus, thanks to the regenerative properties of these organic materials, the physical properties of native peats can be improved (i.e., water holding and aeration capacity) (Çiçek Atikmen and Kütük 2014). It also contributes to increasing the number and activity of microbial communities (Tate 1995, Yilmaz and Alagöz 2005). Therefore, domestic peat should be enriched with various organic materials such as bat guano, chicken and sheep manures, or vermicompost for its competition with imported peat.

Bat guano has microbes with bioremediation capabilities. Thus, it improves soil physical properties such as porosity, aeration, infiltration, and water holding capacity (Dowd 2016). It contains high amount of nitrogen and phosphorous, and so it is mostly used as a fertilizer in agriculture and horticulture (Jayasvasti and Jayasvasti 2018; Misra et al. 2019). Chicken manure, improving soil characteristics (Azmi et al., 2019), is rich in nutrients such as nitrogen, phosphorus, calcium, potassium, and magnesium (Kidinda et al. 2015; Pujiastuti et al. 2018). One of the widely used organic fertilizers is also sheep manure. It plays role in maintaining base cations and buffering of soil acidification (Zhang et al. 2015), and includes nitrogen, potassium, and carbon as inorganic fertilizers (Ansah et al. 2019).

Vermicompost is a nutritive organic fertilizer. Its content exhibits antagonistic ability against soil-borne pathogens (Chaulagain et al. 2017). Thanks to its beneficial composition, it is crucial for soil quality and plant growth. It is also an odorless material that does not carry any pathogen in terms of environment and human health (Bellitürk 2016).

The purpose of the present study is to explore the effects of domestic peat, bat guano, chicken and sheep manures, and vermicompost on the growth, quality, and nutrient contents of basil. Here, it is also aimed to obtain better growing environments by increasing the nutrient content of domestic peat.

Material and method

This study was carried out in Çankırı Karatekin University Research and Application Greenhouse (40°37′32″ N, 33°36′30″ E; 884 m above sea level) under 450–500 μmol m^{-2} s^{-1} light intensity at 25–30 °C with a mean of 70% relative humidity. Basil was selected as the trial plant. Basil grows between 30 and 80 cm in height depending on the climate (Ceylan 1997). The length and width of the leaves is between 1–5 cm and 1–3 cm, respectively. Its flowers are white, lilac, purple, or dark green in clusters (Baydar 2013). The species, within the Lamiaceae family, is intensely used by many industries in fresh and dry forms (Dumanoğlu and Mokhtarzadeh 2021) and also is an ornamental plant (Karık et al. 2014).

The seeds of the plant were obtained from Arzuman, Konya. These seeds were germinated in 48 cell trays containing a mixture of peat and perlite (3:1). After reaching the juvenile plants with 5 cm in height and at least 3 leaves, they were transplanted to the media prepared for the project.

Domestic peat with 50–60% moisture content was provided from a private company from Bolu (Yeniçağa) province, Turkey. pH adjustment was not made in the domestic peat used in the experiment. In order to increase the aeration and water holding capacity of the growing medium, a unit of perlite was added to three units of peat (3:1). Ready-to-use bat guano, chicken and sheep manures, and vermicompost were obtained from private companies. Twelve different growing media were formed by mixing peat + perlite mixture (3:1) and organic materials in different proportions (Table 1).

The experiment was carried out in plastic pots with a volume of 0.5 L containing different growing media by using a completely randomized design with four replications. pH and electrical conductivity (EC) of the growing medium according to Gabriels and Verdonck (1992), its organic matter according to Walkley and Black (1934) was determined. Its nitrogen was found using Kjeldahl method (Bremner 1982). According to Kacar (2009), phosphorous and potassium were recorded in spectrophotometer and flame photometer, respectively. Calcium, magnesium, iron, zinc, manganese, and copper were determined by ICP-OES (Kacar and İnal 2008) (Table 2).

Aesthetic appearance score and crown width (cm) as quality traits were determined. In order to obtain aesthetic

Table 1 Growing media tested in the study

No	Code	Growing media
1	Control	100% Peat/Perlite
2	2%BG	98% Peat/Perlite + 2% Bat guano
3	4%BG	96% Peat/Perlite + 4% Bat guano
4	6%BG	94% Peat/Perlite + 6% Bat guano
5	2%CM	98% Peat/Perlite + 2% Chicken manure
6	4%CM	96% Peat/Perlite + 4% Chicken manure
7	6%CM	94% Peat/Perlite + 6% Chicken manure
8	2%SM	98% Peat/Perlite + 2% Sheep manure
9	4%SM	96% Peat/Perlite + 4% Sheep manure
10	6%SM	94% Peat/Perlite + 6% Sheep manure
11	2%VC	98% Peat/Perlite + 2% Vermicompost
12	4%VC	96% Peat/Perlite + 4% Vermicompost
13	6%VC	94% Peat/Perlite + 6% Vermicompost

Table 2 Some physical and chemical properties of domestic peat and other organic manures

Parameters	Domestic peat	Bat guano	Chicken	Sheep	Vermicompost
pH	7.36	5.00	8.56	9.08	6.04
EC (dS/m)	2.07	7.3	5.31	4.67	7.95
Moisture (%)	-	20	60	18	12
Total humic + fulvic acid (%)	-	0.50	1	0.23	0.54
Organic material (%)	43.19	3	2	1.60	1.90
N (%)	1.34	0.15	0.11	1.50	1.85
P (mg kg^{-1}/%)*	0.027	1	1.5	0.34	1.50
K (mg kg^{-1}/%)	6.40	0.142	0.12	0.30	1.60
Ca (mg kg^{-1})	2014	-	-	-	-
Mg (mg kg^{-1})	67	-	-	-	-
Fe (mg kg^{-1})	0.039	-	-	-	-
Zn (mg kg^{-1})	0.206	-	-	-	-
Cu (mg kg^{-1})	0.751	-	-	-	-
Mn (mg kg^{-1})	1.184	-	-	-	-

* mg kg^{-1} was used for domestic peat and % was used for bat guano, chicken and sheep manures, and vermicompost

appearance score for each plant, the condition of the plants, their appearance, their representation in the pot, vegetative component structure, plant vitality, and brightness were evaluated by a 5-member jury, with a score between 1 and 10 before the plant material was harvested. Here, a final rating of 1–4, 5, and 6–10 are considered sensitive, moderately sensitive, and tolerant to salinity, respectively. Crown width in each pot was determined by measuring the projection diameter of the plant crown vertically in two directions (Çiçek 2021). Then, a total of four plants for each pot were uprooted without harming the roots. After harvest, 10-week plants were washed with tap and deionized waters to prevent soil-induced contamination. Then, plant height (cm) and plant fresh weight (g) were measured before desiccation. After these measurements, harvested plants were desiccated at 70 ± 5 °C for 72 h for the determination of plants' dry weight (g).

0.5 g of dried and ground leaf samples was placed into high-temperature porcelain crucibles and burned at 500 ± 50 °C in accordance with the principles described by Kacar and İnal (2008). By adding 2 mL of 10 N HNO3 to the burned samples in the crucibles, the mineral substances were dissolved by gently heating. Then, the samples were poured into glass measuring volumetric flasks by washing with redistilled water and completed to their degree. The solutions in the measuring flask were filtered through blue banded filter paper (Whatman 42) into plastic extract containers and stored in the refrigerator (4 °C) after tightly closed until analysis.

Total nitrogen in plant was analyzed following Kjeldahl method. Total phosphorus was determined by ICP-OES following the vanadomolybdophosphoric yellow color method. Total potassium was obtained from flame photometry. Total calcium, magnesium, iron, copper, zinc, and manganese were measured by ICP-OES. Measurements of all plant nutrients were made in accordance with the principles described by Kacar and İnal (2008).

Kolmogorov–Smirnov and Levene's tests were carried out to understand normal distribution and variance equality of the data, respectively. One-way analysis of variance was done to find out whether or not the means of treatments were all equal ($P < 0.05$). The variance model of one-way ANOVA given below was used:

$$Y_{ij} = \mu + T_i + e_{ij}$$

where Y_{ij} is the observation from the jth plants of the ith treatment, μ is overall mean, T_i is the random effect of the ith treatment, and e_{ij} is random error.

Hierarchical cluster analysis was also done based on squared Euclidean distances using PAST software in order to visualize the degree of similarity among treatments. The endpoint is a set of clusters, where each cluster is distinct from each other cluster, and the objects within each cluster are broadly similar to each other. In the present study, it was used to group similar treatments based on all studied traits. All these analyses were performed by SPSS.

Results

The study showed that there were significant differences among treatments for aesthetic appearance score, height, and fresh and dry weights of plants ($P < 0.05$) with the exception of crown width. Control and 6%BG exhibited the lowest and highest aesthetic appearance score (4.6, 10), crown width (2.9 cm, 6.3 cm), height (15.6 cm, 24.6 cm), and fresh (11.3 g, 34.6 g) and dry (2.2 g, 5.9 g) weights of plants, respectively. Following bat guano, vermicompost had the highest values for the studied traits (Table 3).

According to the result of variance analysis, there were significant differences among treatments for all studied plant nutrients ($P < 0.05$). Accordingly, control had the lowest P (0.1 gkg^{-1}), Ca (2.3 gkg^{-1}), Fe (20.5 $mgkg^{-1}$), Cu (5.4 gkg^{-1}), and Zn (20.7 gkg^{-1}). The lowest N (2.5 gkg^{-1}), K (0.5 gkg^{-1}), and Mg (0.3 gkg^{-1}) were obtained from 2%SM. 6%BG had the lowest manganese (22.7 gkg^{-1}) but the highest P (0.7 gkg^{-1}), Mg (0.7 gkg^{-1}), Fe (124.3 $mgkg^{-1}$), and Cu (14.1 $mgkg^{-1}$). The highest N (3.4 gkg^{-1}), K (1.5 gkg^{-1}), and Zn (51.8 $mgkg^{-1}$) were provided from 6%CM. 6%SM showed the highest Ca (3.6 gkg^{-1}) and Mn (59.3 gkg^{-1}). Vermicompost was the second successful treatment for N, K, Ca, Cu, and Mn (Table 4).

According to the hierarchical cluster analysis (Fig. 1), four different groups could be distinguished at the 2.0 distance unit. Both control and 6%BG formed two groups

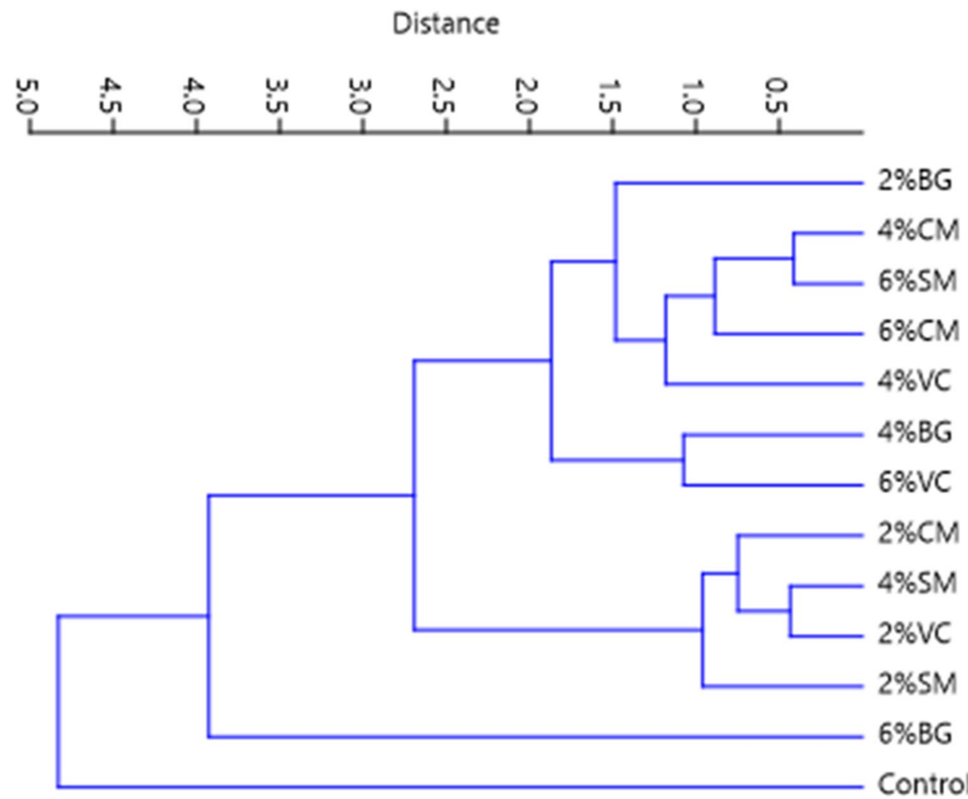
Table 3 Effects of organic materials on quality and growth traits of basil plants

Treatments	Aesthetic appearance score (1–10)	Crown width (cm)	Plant height (cm)	Plant fresh weight (g)	Plant dry weight (g)
Control	4.6 ± 0.3	2.9 ± 0.5	15.6 ± 0.8	11.3 ± 0.9	2.2 ± 0.2
2%BG	8.0 ± 0.5	5.0 ± 1.3	21.8 ± 0.8	27.1 ± 0.4	4.3 ± 0.2
4%BG	9.5 ± 0.0	5.9 ± 1.2	22.6 ± 1.2	30.5 ± 1.2	5.0 ± 0.3
6%BG	10.0 ± 0.0	6.3 ± 1.3	24.6 ± 1.8	34.6 ± 1.0	5.9 ± 0.3
2%CM	6.9 ± 0.1	4.3 ± 0.9	17.4 ± 0.5	19.7 ± 1.1	3.0 ± 0.1
4%CM	8.4 ± 0.3	5.2 ± 1.0	20.8 ± 0.6	21.9 ± 1.2	3.1 ± 0.1
6%CM	8.7 ± 0.1	5.4 ± 1.1	23.3 ± 1.2	22.4 ± 0.7	3.4 ± 0.1
2%SM	6.7 ± 0.1	4.2 ± 0.9	17.4 ± 0.7	15.2 ± 0.4	2.9 ± 0.1
4%SM	7.3 ± 0.1	4.5 ± 1.0	18.7 ± 0.9	18.3 ± 0.5	3.4 ± 0.1
6%SM	8.7 ± 0.2	5.4 ± 1.1	21.3 ± 0.5	21.4 ± 0.4	3.3 ± 0.2
2%VC	7.5 ± 0.2	4.7 ± 1.0	17.8 ± 0.8	19.0 ± 0.9	3.4 ± 0.1
4%VC	9.0 ± 0.0	5.6 ± 1.1	20.2 ± 0.6	22.3 ± 1.1	4.1 ± 0.2
6%VC	9.6 ± 0.1	6.0 ± 1.2	22.6 ± 1.0	25.6 ± 0.7	4.3 ± 0.1
Mean	8.1 ± 0.1	5.0 ± 1.1	20.3 ± 0.9	22.3 ± 0.8	3.7 ± 0.2
Min–Max	4.6–10	2.9–6.3	15.6–24.6	11.3–34.6	2.2–5.9
P	0.000	0.671	0.000	0.000	0.000

Table 4 Effects of organic materials on plant nutrients of basil plants

Treatments	N (gkg^{-1})	P (gkg^{-1})	K (gkg^{-1})	Ca (gkg^{-1})	Mg (gkg^{-1})	Fe ($mgkg^{-1}$)	Cu ($mgkg^{-1}$)	Zn ($mgkg^{-1}$)	Mn (gkg^{-1})
Control	2.6 ± 0.0	0.1 ± 0.0	0.6 ± 0.0	2.3 ± 0.1	0.4 ± 0.0	20.5 ± 0.3	5.4 ± 0.5	20.7 ± 0.2	28.0 ± 2.6
2%BG	2.7 ± 0.0	0.6 ± 0.0	0.8 ± 0.0	2.7 ± 0.2	0.6 ± 0.0	29.3 ± 2.1	12.5 ± 0.1	35.9 ± 0.4	30.1 ± 0.7
4%BG	2.9 ± 0.0	0.6 ± 0.0	0.8 ± 0.0	3.3 ± 0.2	0.7 ± 0.0	93.0 ± 1.4	13.9 ± 0.5	39.5 ± 0.4	32.5 ± 1.4
6%BG	2.9 ± 0.0	0.7 ± 0.0	0.8 ± 0.0	3.5 ± 0.2	0.7 ± 0.0	124.3 ± 2.7	14.1 ± 0.6	45.5 ± 0.9	22.7 ± 2.6
2%CM	2.7 ± 0.1	0.3 ± 0.0	0.6 ± 0.0	2.4 ± 0.1	0.4 ± 0.0	28.7 ± 0.8	8.1 ± 0.1	45.0 ± 0.6	41.8 ± 1.4
4%CM	2.9 ± 0.0	0.3 ± 0.0	1.1 ± 0.0	2.6 ± 0.0	0.5 ± 0.0	33.1 ± 1.1	8.5 ± 0.2	47.8 ± 0.4	47.4 ± 3.2
6%CM	3.4 ± 0.1	0.4 ± 0.0	1.5 ± 0.2	2.7 ± 0.0	0.6 ± 0.0	43.4 ± 0.8	10.5 ± 1.5	51.8 ± 0.5	49.5 ± 0.7
2%SM	2.5 ± 0.1	0.2 ± 0.0	0.5 ± 0.0	3.3 ± 0.0	0.3 ± 0.0	42.3 ± 2.9	10.5 ± 0.5	43.7 ± 1.4	47.5 ± 1.2
4%SM	2.6 ± 0.0	0.2 ± 0.0	0.7 ± 0.0	3.5 ± 0.0	0.3 ± 0.0	60.4 ± 3.9	11.1 ± 0.3	48.1 ± 0.3	55.6 ± 1.9
6%SM	2.8 ± 0.1	0.3 ± 0.0	0.8 ± 0.0	3.6 ± 0.0	0.3 ± 0.0	67.3 ± 1.1	12.9 ± 0.5	51.6 ± 0.6	59.3 ± 1.2
2%VC	2.8 ± 0.0	0.2 ± 0.0	0.6 ± 0.0	2.6 ± 0.1	0.4 ± 0.0	24.0 ± 0.9	9.5 ± 0.7	32.2 ± 0.6	41.1 ± 1.1
4%VC	3.1 ± 0.2	0.2 ± 0.0	1.0 ± 0.1	2.9 ± 0.0	0.4 ± 0.0	30.9 ± 1.9	11.0 ± 0.6	35.9 ± 0.9	49.2 ± 2.5
6%VC	3.1 ± 0.1	0.3 ± 0.0	1.3 ± 0.0	3.2 ± 0.0	0.4 ± 0.0	51.9 ± 3.8	12.3 ± 0.2	40.6 ± 0.5	51.1 ± 1.9
Mean	2.9 ± 0.1	0.3 ± 0.0	0.9 ± 0.0	3.0 ± 0.1	0.5 ± 0.5	49.9 ± 1.7	10.8 ± 0.5	41.4 ± 0.6	42.8 ± 1.7
Min–Max	2.5–3.4	0.1–0.7	0.5–1.5	2.3–3.6	0.3–0.7	20.5–124.3	5.4–14.1	20.7–51.8	22.7–59.3
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Fig. 1 Dendrogram of hierarchical cluster analysis based on Squared Euclidean distances among treatments



individually. The third group included 2%SM, 2%VC, 4%SM, and 2%CM treatments. The fourth group consisted of seven other treatments mainly including 4% and 6% organic materials.

Discussion

All in all, plants with "94% Peat/Perlite + 6% Bat guano" revealed the best performance in growth and quality traits of basil in the present study. This treatment also had the highest phosphorous content in basil leaves. Similarly, Hatibu (2018) reported that 80 mg P kg^{-1} of guano among the explored guanos would provide sufficient phosphorous for the growth of *Oryza sativa.*

High-rate vermicompost applied in the study showed the second performance in terms of growth and quality traits as well as nitrogen and potassium contents of basil without phosphorous. In a study conducted in *Ocimum basilicum* L. cv. "Vikas Sudha" by Anwar et al. (2005), the combination of vermicompost at 5 t ha^{-1} + 50:25:25 kg ha^{-1} exhibited the best growth traits and highest nitrogen, potassium, and phosphorous contents. Shahriari et al. (2015), exploring the vermicompost effect on growth traits and essential oil of basil, also pointed out that vermicompost was a suitable choice in maintaining agriculture.

Although sheep and chicken manures had the same pattern on quality traits of basil, chicken manure was more effective on height and fresh weight of plants, and sheep manure on its dry weight in the present study. Likewise, earlier researches stated that chicken manure increased the growth traits of *Gynura pseudochina* (L.) DC (Perkasa et al. 2016), *Zea mays* (Mahmood et al. 2017), *Ocimum basilicum* L. cv. "Genovese" (Mohamed et al. 2017), *Brassica oleracea* (Pujiastuti et al. 2018), *Ficus carica* (Azmi et al. 2019), and *Ocimum basilicum* L. (Pramod et al., 2020). Another study (Ghimire et al. 2019) showed that the combination of 50% or more N urea and chicken manure had higher growth and quality parameters of *Lactuca sativa.* Although chicken manure outperformed sheep manure in the present study, it increased plant height in *Phaseolus vulgaris* L. (Bucagu et al. 2017), plant height, dry weight, and macronutrients in *Mimosa caesalpiniifolia* (De Souza et al. 2021), and growth in *Vitis vinifera* (Hong et al. 2018). Moreover, Kidinda et al. (2015) indicated that the combination of chicken manure and mineral fertilizers is more effective in increasing nutrient availability of *Zea mays* despite the fact that chicken manure had no improvement in soil nutrient.

The increasing doses of organic manures tested in the present study had higher nutrient contents. Besides, basil plants applied chicken manure had higher nitrogen, potassium, and phosphorous contents compared to sheep manure. The higher nutrient contents in *Ocimum basilicum* grown with organic manure reported by Bufalo et al. (2015) were parallel to those in the present study. At the same time, it was reported that organic (Gavric et al. 2021) and compost (Toaima et al. 2022) manures increased the fresh weight of basil. Dalorima et al. (2021) also emphasized that notably vermicompost and chicken manure increased plant heights.

Conclusions

As considered the results from the study, it could be revealed that “94% Peat/Perlite + 6% Bat guano” should be used in planting basil. However, doses of different organic manures and their combinations should be investigated in order to obtain better growth and quality traits as well as physiological traits. Meanwhile, this study also unveiled that the effect of domestic peat from Turkey can be significantly increased with organic manures.

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Data availability The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Code availability Not applicable.

Declarations

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Conflict of interest The authors declare no competing interests.

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