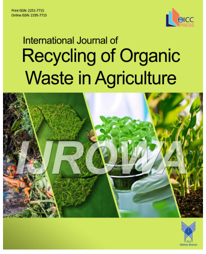

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Optimizing yield properties of bitter melon (*Momordica charantia* L.) plant by integrative application of poultry manure

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Original Research

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Abstract:

Purpose: Poultry manure has promising effects on bitter melon fruit yield and can be considered as a suitable substitute for chemical fertilizers. This study was conducted to determine the effect of chicken (CM) and turkey manure (TM) with a control on the bitter melon morphology and yield at the Agriculture Faculty research and application area of Bolu Abant İzzet Baysal University, Bolu, Türkiye in 2021 year.
Method: The treatments were: CM with 10 t/ha (CM1), 12.5 t/ha (CM2), 15 t/ha (CM3), 17.5 t/ha (CM4), TM with 10 t/ha (TM1), 12.5 t/ha (TM2), 15 t/ha (TM3), 17.5 t/ha (TM4).
Results: The results showed that TM1 application increased plant height (119.67 cm), and CM3 application increased fruit length (10.20 cm) and diameter (4.20 cm). Also, CM3 application decreased 50% flowering (70.33 days) and first fruit setting days (79.33 days), and increased fresh (142.33 kg/ha) and dry fruit (5.87 kg/ha) yield values. Correlation analysis revealed the highly significant positive correlations (between the r = 0.801**-r = 1**) in the most of the examined properties. Principal component analysis (PCA) of the examined properties showed a total of 81.4% of the total variation, and reveal to distinguish significant groupings among the examined properties and poultry manure applications.
Conclusion: As a conclusion, both CM and TM applications showed positive effect on the bitter melon. Especially, CM3 and CM4 applications had the highest effect on the fruit yield.
CM3 – 4 and TM4 applications can serve as a viable and effective nutrient source for promoting growth and maximizing bitter melon yield.

Keywords: Sustainable agriculture; *Momordica charantia* L.; Fruit yield; PCA

1. Introduction

The agricultural sector itself is a major source of pollution and is the sector most affected by pollution factors (Moldavan et al., 2024). There are many studies that emphasize the positive effect of chemical fertilizers on crop yield, addressing certain nutrient deficiencies and supporting rapid plant growth. However, it reduces the organic matter content of the soil and poses a serious environmental risk in the long term and contamination of groundwater and surface water with nutrient runoff, resulting in eutrophication and harmful algal bloom. The excessive use of fertilizers causes serious environmental degradation, resulting in lower crop yields and economic losses. In addition, over-fertilization to increase productivity, especially nitrate-containing fertilization, not only causes wasteful consumption but also can potentially pollute water-courses with plant nutrients in general and nitrates in particular (Bijay-Singh, 2021). Many approaches such as agroecology, organic farming, biodynamic agriculture, nature-inclusive agriculture have been suggested by researchers to ensure sustainable production, environmental protection and food security. Sustainable production systems also have the potential to become self-sufficient in nitrogen through the recycling of farm manures and crop residues and reducing nutrient losses.

Organic manures reduce the harmful effects of chemical fertilizers by producing humus and increasing the activity of the soil microbial community. The use of non-chemical sources such as poultry manure can increase soil fertility by increasing the absorption efficiency of nutrients in crops

and improve yield and crop quality. Poultry manure has become a promising source of organic fertilizer that makes plant production sustainable in agricultural environments (Yaldiz and Camlica, 2023).
Nowadays, organic farming practices are becoming more important day by day. Application of organic manures can reduce environmental pollution as well as dependence on chemical N fertilizers and greenhouse gas emissions from chemical N fertilizer production (He et al., 2023). There is no doubt that the demand for organic food is steadily increasing in the world. These preferences suggest that the possibilities of using various organic manures in agriculture has been emphasizing the need to investigate in more detail. Poultry manure is the most concentrated form of organic manures that contains nitrogen, phosphorus and potassium (Debska et al., 2022). It is also an avaluable organic raw material for improving soil fertility and increasing crop yields. The use of this organic ameliorant contributes to an increase in the humus content in the soil by $0.04-0.05\%$. A large number of groups of microorganisms are present and multiply in the compost during the ripening period (Buryak et al., 2023). One of the resources applied to the soil to increase the organic matter content of the soil is chicken manure. Chicken manure contains nitrogen, phosphorus and potassium, as well as microelements that are important for the soil, such as calcium, magnesium, copper and zinc. The fact that 65% of the nitrogen, 50% of the phosphorus, and 75% of the potassium in chicken manure can be utilized by the plant within the first year of fertilizer application indicates the importance of this fertilizer. Turkey manure is an exceptionally valuable natural fertilizer, packed with phosphorus and nitrogen-two essential nutrients for plant growth. In addition, turkey manure contains significantly higher levels of calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), and manganese (Mn) compared to other manure (Yaldız et al., 2019). The application of poultry manure, including turkey manure, increases the soil's cation exchange capacity (CEC), which improves the soil's ability to hold onto essential nutrients (Zhao et al., 2017). It reduces the dependency on synthetic fertilizers, which can be expensive and harmful to the environment. Additionally, it provides an efficient means of managing turkey farm waste (Vogt et al., 2014). In these contexts, the chicken and turkey manures were applied to assess their impact on the morphology and yield characteristics of bitter melon.
A noteworthy member of the Cucurbitaceae family; *Momordica charantia* L. (bitter melon) is an annual, slender, climbing plant (Gayathry and John, 2022). The plant, whose fruits and leaves are rich in minerals and vitamins, is especially rich in iron, calcium, phosphorus, C and B vitamins. It also contains β-carotene, potassium, magnesium, vitamin A and zinc. The seed membranes of ripe fruits are a good source of lycopene. Injectable preparations derived from bitter melon juice and fruit have been traditionally used worldwide to lower blood sugar levels (Manabe et al., 2003). In addition, it is known to have antimutagenic, antitumor, antiviral, antioxidant, antihepatoxic, antiulcerogenic (Gayathry and John, 2022), antibacterial (Jayaraj et al., 2024), antidiabetic, antigenotoxic, contraceptive, antipyretic, carminative effects (Patel et al., 2010). There are many studies showed that free radical scavenging of *Momordica charantia* L. fruit extract has beneficial activity against superoxide and hydroxyl radicals that cause pathophysiological changes. Flavone aglycones contained in bitter melon fruit is preferred for women in the menopause period because it has a phytoestrogenic effect (Sundarrajan et al., 1999). The significant increase in bitter gourd production is undoubtedly remarkable. However, bitter gourd growers continue to face several challenges in the field conditions, including issues such as pests and diseases, high labor costs, limited availability of inputs, weather-related problems like drought and flooding, variability in production, and a lack of awareness regarding plant protection measures (Jayapalan and Sushama, 2001).
In order to achieve high quality in terms of environment and human health, it is strongly recommended to encourage cultivation methods such as biological or organic manures. As can be understood from the literature and information provided above, our study is important in terms of eco-friendly agricultural practices of bitter melon and its introduction to market in accordance with the required standards regarding functional food, which is suitable for medical use. At the end of this study, the effects of poultry manure and different dose applications on the yield values of bitter melon will be determined and the deficiencies in this regard will be eliminated, which strengthened the innovative aspect of this study. Therefore, the most important aim of this study is to popularize the use of organic fertilizers, and the second important aim is to optimize manure management practices to increase bitter melon growth and productivity. As a result, the current study will be the first example of evaluating the effects of chicken and turkey manure doses on yield and yield components of bitter melon. Thus, the appropriate doses of chicken and turkey manure, which stand out in terms of agricultural properties, will be determined and will constitute a resource for future studies.

2. Materials and methods

Experimental site

The field experimental site was located at the research and application area of the Agriculture Faculty ($40°44'45''$ N, $31°37'46''$ E; 752 m). The soil properties of the experimental area were clay, 7.56 value of pH, 3.71% of organic matter content, 0.50 kg/ha phosphorus content, 1083.10 kg/ha potassium ratio and 0.0383% salt (DPAF, 2019).
The experiment soil can be classified as clayey sand according to European Soil Classification System (ESCS) laboratory analysis (Librić et al., 2017). During the vegetation period (from May to October), mean climatic data were recorded for 2021 follows: 15.4 °C temperature; 67.2 mm rainfall; 71.75% humidity (BMGD, 2022).

Plant materials

The seeds of the *Momordica charantia* L. were obtained from local farmer of Bolu, Türkiye. In this study, doses of the TM and CM were applied as reported by previous studies (Yaldiz et al., 2019).

Experimental design and treatment details

Seeds were sown in plastic pots (400 mm diameter) filled with 3.5 kg of field soil in 14 April 2021. Pots were placed in a climate chamber (27 °C − 65% humidity). Until the seedlings have 5 − 6 leaves under climate chamber condition, no fertilizer or chemical application was applied to the plant. When the seedlings reached 5 − 6 leaves (about 10 cm), they were transplanted to the open-air field condition on 12 May 2021, and experiment was conducted in the randomized complete block design with three replications under field condition. Each experimental plot consisted of five rows, with a distance of 50 cm between each row and 40 cm between each plant, and five rows each having six plants were maintained in the plot. For the distance between the plots, a meter block was considered. Full dose of TM (10 t/ha, 12.5 t/ha, 15 t/ha and 17.5 t/ha) and CM (10 t/ha, 12.5 t/ha, 15 t/ha and 17.5 t/ha) were applied 2 weeks before transplanting in field conditions. The chemical properties and treatment codes of used organic manures in the study were given in Tables 1 and 2.

Cultural practices

Bitter melon was regularly watered with a drip irrigation system. No pesticide was used in this study. Bitter melon fruits were harvested by hand when they ripened and reached orange color; then, the fruits were dried in a thermal drying compartment at a temperature of 35 °C.

Data collection

In order to determine the morphology and pomological properties, the height of the plants was evaluated by measuring with a meter and expressing the values obtained in cm, and the fruit lenght, diamater and flesh thickness were determined by measuring with a caliper as cm after each fruit harvest. The values of fresh fruit weight, expressed in kg/ha and gram per plant, was determined immediately after harvesting by weighing with an analytical balance, with a precision of 0.01 g. The dried fruit weight values, expressed in kg/ha and gram per plant, were determined after drying

Table 1. The properties of experimental used organic fertilizers.

Properties	Unit	Chicken manure	Turkey manure
pH		7.08	7.60
Lime	%	-	-
EC	micromhos/cm	6.68	5.20
Sand	%	-	-
Clay	%	-	-
Mile	%	-	-
Organic matter	%	89	90
N	%	0.70	2.03
P	%	0.13	0.13
K	%	0.44	0.43
Ca	%	4.32	1.50
Mg	ppm	0.77	0.73
Fe	ppm	0.09	0.07
Zn	ppm	0.048	0.42

Table 2. Treatment codes and description of chicken and turkey manures.

Treatment code	Treatment description	Rate of application
Control	Control	Control
CM1	Chicken manure	10 t/ha
CM2	Chicken manure	12.5 t/ha
CM3	Chicken manure	15 t/ha
CM4	Chicken manure	17.5 t/ha
TM1	Turkey manure	10 t/ha
TM2	Turkey manure	12.5 t/ha
TM3	Turkey manure	15 t/ha
TM4	Turkey manure	17.5 t/ha

the fruits in a drying oven. The number of seeds of all the fruits harvested were determined in each fruit. The weight in grams of 1000 seeds sampled from fruit were determined by counting 4×100 seeds.

Statistical analysis

The statistical analysis was conducted using one-way analysis of variance (ANOVA) using JMP statistical software. The significance of the examined properties results ($p < 0.05$) was determined using the LSD test. The correlation and PCA analyses were determined by using JMP statistical software and XLSTAT Statistical Software. The heat map analysis was clustered using correlation distance and averages by using ClustVis (https://biit.cs.ut.ee/clustvis/) (Yaldız and Çamlıca, 2024).

3. Results and discussion

50% flowering time (days)

The values for the 50% flowering time are shown in Fig. 1. 50% flowering values in bitter melon organic fertilizer applications were found to be statistically significant. It has been determined that 50% flowering time of bitter melon vary between 54.00 – 70.33 days. In this study, the general mean of 50% flowering time was 61.86 days. The earliest 50% flowering time was obtained with the application of CM1 with 54.00 days, followed by control (55 days) and TM4 applications (59.67 days). The latest 50% flowering time was obtained with 70.33 days from CM3 dose, and this value was followed by 65.33 day with TM1 dose application.

When the fertilizers applied in the study were compared, it was determined that TM4 with 59.67 days and CM1 with 54.00 days had a positive effect on the number of days to 50% flowering. It is thought that the earliest 50% flowering is achieved from the application of CM due to the higher potassium and calcium content of CM compared to turkey manure. The 50% flowering time ranged from 54.00 to 70.33 days which was significantly higher than the findings of Arslanoğlu and Hendekçi (2012) (40 days) and Yaldız (2013) (42 days in the field, 38 days in the greenhouse). However, Mulani et al. (2007) reported that 50% flowering time of bitter melon ranged from 54 to 67.67 days, which

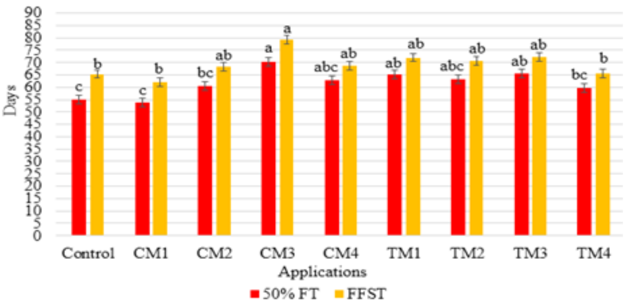

Figure 1. 50% FT and FFST values of bitter melon grown under different poultry manures.
*50% FT: 50% Flowering time, FFST: First fruit setting time, CM: Chicken manure, TM: Turkey manure, Means in the bar chart followed by different letters (a, b and c) are significantly ($p < 0.05$) different by least significant difference test.

is similarly with our findings. In another study conducted by Kishorkumar et al. (2025) found 50% flowering time between 39.80 – 62.80 days, which is partly similar with our results. It is thought that the reason for the differences in the values obtained as a result of the study is due to the type of fertilizer applied and ecological conditions.

First fruit setting time (days)

The values regarding the first fruit setting time of bitter melon fertilizer applications in the experiment are shown in Fig. 1.

There were significant variations found among the poultry manure applied in terms of first fruit setting time (Fig. 1). In our study, while the first fruit setting time of bitter melon varied between 62 – 79.33 days, the general mean of the first fruit setting time was found to be 69.4 days. The earliest first fruit setting was obtained with CM1 application, this value was followed by the control application with 65.33 days and TM4 applications with 65.67 days. While the latest fruit setting took 79.33 days from CM3 dose, this value was followed by TM3 dose application with 72.33 days. During the vegetation period, fruit setting began to appear on the plant due to the decrease in the amount of rainfall in July-August.

When the fertilizers applied in the study were compared among themselves, it was determined that CM1 (62 days) and TM4 (65.67 days) had a positive effect on the number of days to first fruit setting. It is thought that the reason why chicken manure has a positive effect on the number of fruiting days due to the nutritional elements contained in chicken manure. Tavalı et al. (2014) reported that the nutritional elements contained in chicken manure promoted the plant growth and development, and increased the earlier fruit ripening of the plant. In our study, the first fruit setting period (62 – 79.33 days) was higher than the results of Yaldız (2013) (46 days in the field, 43 days in the greenhouse). This is because it has been reported that fruit setting time related fertilizer application and ecological conditions.

Plant height (cm)

As shown in Fig. 2, plant height values were found to be statistically insignificant in bitter melon PM applications. It was determined that plant height values varied between 82.23 – 119.17 cm, and the general mean of plant height was determined to be 106.77 cm. While the highest plant height value was obtained from TM1, followed by TM4 (114.20 cm) and CM4 (112.33 cm) applications, respectively. The lowest plant height value was obtained from the control with 82.23 cm, and this value was followed by CM3 application with 97.61 cm.

Among chicken manure applications, it was determined that CM4 (112.33 cm) application had a positive effect on the plant height, while among turkey manure applications, TM1 dose (119.17 cm) had a positive effect. The EC value of turkey manure is lower than that of chicken manure, which is thought to boost plant height. Parida and Das (2005) reported that salt stress inhibits the growth and development of plants by causing osmotic and ion stress. The studies showed that PM application have a positive effect on medicinal and aromatic plants, and they increase vege-

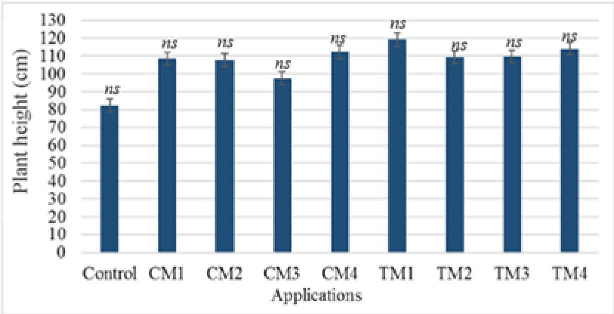

Figure 2. Plant height values of bitter melon grown under different poultry manures.
*CM: Chicken manure, TM: Turkey manure, *ns*: not significant, Means in the bar chart followed by *ns* letter is not significantly ($p < 0.05$) different by least significant difference test.

tative growth and productivity values by having a positive effect on the physical, chemical and biological properties of the soil (Sharma et al., 2011).

Pomological properties (fruit lenght, fruit diameter and fruit flesh thickness)

In this study, fruit lenght values were found to be statistically significant in different poultry manures. It has been determined that fruit length values vary between 8.47 – 11.15 cm and the general mean of fruit lenght was determined to be 9.62 cm. The highest fruit length value was obtained from the CM3, followed by TM4 (10.20 cm) and TM2 (9.99 cm) applications. The lowest fruit lenght was obtained from the control application with 8.47 cm, and this value was followed by CM2 (8.95 cm) application. When the applied all organic manures were compared, it was determined that CM3 and TM4 had a positive effect (Fig. 3).

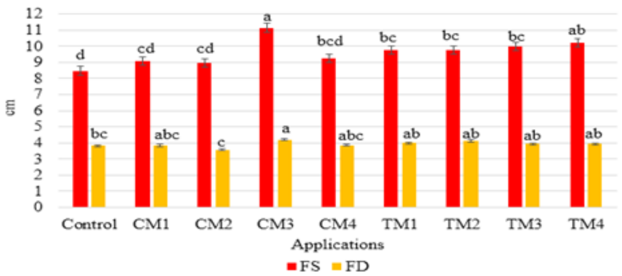

Figure 3. FS and FD values of bitter melon grown under different poultry manure.
*FS: Fruit size, FD: Fruit diameter, CM: Chicken manure, TM: Turkey manure, Means in the bar chart followed by different letters (a, b, c and d) are significantly ($p < 0.05$) different by least significant difference test.

As a result of the research, fruit diameter values in PM applications were found to be statistically significant (Fig. 3). The fruit diameter values of bitter melon were determined to be between 3.56 – 4.20 cm. The highest fruit diameter value of 4.20 cm was obtained from CM3, followed by TM2 (4.13 cm) and TM1 (4.00 cm) applications, where the general mean of fruit diameter was 3.92 cm. The lowest fruit diameter was obtained from the CM2 application, and followed by the control application with 3.81 cm.
Fruit flesh thickness values of bitter melon were found to be statistically significant in PM applications (Fig. 4). Fruit flesh thickness values of bitter melon were determined to be between 4.09 – 5.27 mm with a mean of 4.85 mm. The highest flesh thickness value was obtained from TM2 application, and followed by TM3 application with 5.24 mm and CM4 applications with 5.03 mm, respectively. While the lowest flesh thickness was obtained from the control application with 4.09 mm, this value was followed by TM1 dose application with 4.38 mm.

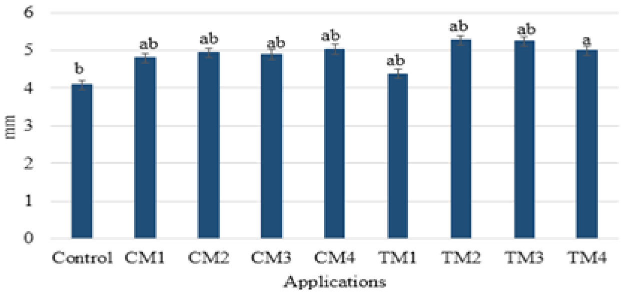

Figure 4. FFTvalues of bitter melon grown under different poultry manures.
*FFT: Fruit flesh thickness, CM: Chicken manure, TM: Turkey manure, Means in the bar chart followed by different letters (a, b and c) are significantly ($p < 0.05$) different by least significant difference test.

The fruit lenght of bitter melon in this study was generally within the usual range reported in a previous study (Yaldiz et al., 2014; Karaman et al., 2018; Çamlıca and Yaldız, 2019; Prashanthi and Deepanshu, 2021; Alhariri et al., 2022), and the obtained results were found partly similar with Bhati et al. (2023) who reported the fruit length of bitter melon between 4.54 – 10.34 cm. However, Mulani et al. (2007), Resmi and Sreelathakumary (2016) and Tyagi et al. (2018) reported higher results than our findings. The fruit diameter values were found higher than reported by Bhati et al. (2023). Kishorkumar et al. (2025) found fruit length and dimeter values partly similar with our findings in seventy-five genotypes of bitter gourd between 5.60 – 26.34 cm and 1.63 – 4.95 cm, respectively. Similarly, Mehta et al. (2024) reported that furit length and dimeter values changed between 9.33 – 16.53 and 3.13 – 4.28 cm in twenty-seven genotypes of bitter gourd, which were found partly similar with our results. Differences in the fruit length and diameter values between this study and others could be attributed to genotypic differences, growing conditions or environmental factors. According to the results of the study, it was determined that CM4 (5.03 mm) and TM2 (5.27 mm) had a positive effect on fruit flesh thickness. These results were in close agreement with results present in the literature (Mulani et al., 2007; Tan et al., 2016; Karaman et al., 2018).

Fresh fruit weight (kg/ha, g/plant)

Fresh fruit weight values were found to be statistically significant in different PM applications (Fig. 5). The fresh fruit weight values ranged from 24.69 – 142.33 kg/ha with a mean of 61.48 kg/ha. The highest fresh fruit weight value was obtained from CM3 application, followed by TM4 (70.52 kg/ha) and CM4 applications (65.96 kg/ha). The lowest fresh fruit weight was obtained from the control application with 24.69 kg/ha, and followed by CM1 application with 34.76 kg/ha.

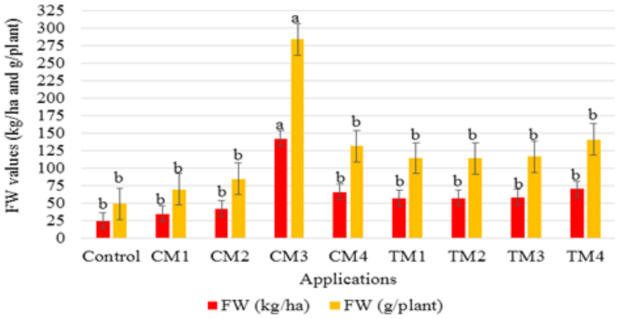

Figure 5. FW values of bitter melon grown under different poultry manures.
*FW: Fresh weight, CM: Chicken manure, TM: Turkey manure, Means in the bar chart followed by different letters (a and b) are significantly ($p < 0.05$) different by least significant difference test.

The effect of the CM and TM applications on the fresh fruit weight was statistically significant at the level of 5%. The fresh fruit weights in bitter melon was changed between 49.39 – 284.73 g/plant with a mean of 122.96 g/plant (Fig. 5). The highest fresh fruit weight was found in the application of the CM3 (284.65 g/plant) and TM4 (141.04 g/plant) and CM4 (131.91 g/plant) compared to the other applications. The lowest fresh fruit weight was obtained from the control application with 49.39 g/plant, followed by CM1 application with 69.51 g/plant.

Among the PM applications, CM3 and TM4 doses had a positive effect on fresh fruit weight. Furthermore, chicken manure positively affects fresh fruit weight due to the high amount of calcium it contains. Similarly, Parvin et al. (2015) reported that calcium not only improves the morphological and physiological characteristics of the plant but also significantly increases its yield characteristics.

In addition, our results were consistent with the previous observation on the fresh fruit weight of bitter melon using poultry manure compared to chemical fertilizer (Yaldız et al., 2019). However, our values were greater than that reported by Yaldiz et al. (2014) report which determined that fresh fruit weight of bitter melon was 55.66 kg/ha in the field and 30.07 kg/ha in the greenhouse condition. It is thought that the reason for the difference between studies due to organic fertilizer application and ecological conditions.

Among chicken manure applications, CM3 (284.65 g/plant) had a positive effect on fresh fruit weight, while among turkey manure applications, TM4 (141.04 g/plant) had a positive effect. It is thought that the high fresh fruit weight obtained from chicken manure applications due to the high magnesium content of chicken manure. Aktaş and Ateş (1998) stated that magnesium increases the rate of photosynthesis by having a positive effect on the amount of chlorophyll and therefore increases product yield. It is seen that our fresh fruit weight values (49.39 – 284.73 g/plant) results are partly similar with the findings of Resmi and Sreelathakumary (2016) (116.01 – 578.75 g/plant) and Panigrahi et al. (2024) (20.36 – 86.11 g). Our results were found lower than Asna et al. (2024), who reported fresh fruit weight between 124.05 – 8568.61 g. This can be explained by the genetic differences, applications, growth conditions, climatic data and soil properties of the experimental area. In addition, it has been stated that fresh fruit weight increases with the application of poultry manure (Yaldız et al., 2019). Similarly, it was reported that fresh fruit weight varies depending on daily temperature change (Arslanoğlu and Hendekçi, 2012).

Dried fruit weight (kg/ha, g/plant)

The results of the dry fruit weight values indicated that different types and doses of PM had a statistically significant effect on the dry fruit weight values of the bitter melon. The weight values of dried fruit were determined between 1.15 – 5.87 kg/ha with a mean 2.67 kg/ha. The highest dried fruit weight was obtained from the application of CM3, and followed by TM4 3.05 kg/ha) and CM4 (2.76 kg/ha), respectively. The lowest dried fruit weight was obtained from the control application with 1.15 kg/ha, and this value was followed by CM1 dose application with 1.68 kg/ha (Fig. 6).

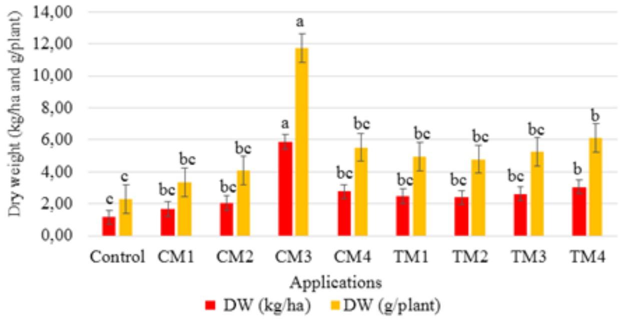

Figure 6. FW and DW values of bitter melon grown under different poultry manures.
*FW: Fresh weight, DW: Dry, CM: Chicken manure, TM: Turkey manure, Means in the bar chart followed by different letters (a, b and c) are significantly ($p < 0.05$) different by least significant difference test.

Among the chicken manure doses, CM3 (5.87 kg/ha) had a positive effect on dried fruit weight, while among the turkey manure doses, it was determined that TM4 (3.05 kg/ha) doses had a positive effect. It is thought that the positive effect of chicken manure on dry weight may be due to its high amount of P and Ca contains.

As understood from the research results, dried fruit weight values were found to be statistically significant in bitter melon PM applications (Fig. 6). The weight values of bitter melon dried fruit were found to be between 3.36 – 11.75 g/plant. In this study, where the general mean of dried fruit weight was 5.34 g/plant, the highest dried fruit weight value was obtained from CM3 application, and followed by TM4 (6.11 g/plant) and CM4 (5.53 g/plant) applications. The lowest dried fruit weight was obtained from the control application with 2.30 g/plant, and this value was followed by CM1 application with 3.36 g/plant.

Among the chicken manure doses, CM3 (11.75 g/plant) had a positive effect on dried fruit weight, while among the turkey manure doses, TM4 (6.11 g/plant) dose had a positive effect. It is thought that the reason why chicken manure has a positive effect on dry weight due to its plant nutritional elements contains. These findings were partly similar to Çamlıca and Yaldız (2019), who reported dried fruit weight changed between 0.93 and 5.75 g/plant in bitter melon.

Kara and Erel (1999) revealed that due to increasing doses of chicken manure, the total water-soluble salt and Fe content of the soil increased and the soil Ph content decreased, and they stated that chicken manure caused an increase in dry weight.

Number of seeds (number/fruit) and 1000 seed weight (g)

Seed number values in bitter melon were found to be statistically significant (Fig. 7). The seed number values of bitter melon were determined to be between 15.97 – 23.62, and the general mean of seed number was determined to be 19.6 number. The highest seed number value was obtained from CM3 application, followed by TM3 applications with 22.43 and TM2 applications with 20.86 number. The lowest seed number was obtained from the control application with 15.97 number, followed by CM1 application with 16.26 number. Among the chicken doses, the seed number was 23.63 with CM3 application. Among the turkey applications, it was determined that TM3 (22.43 number) had a positive effect.

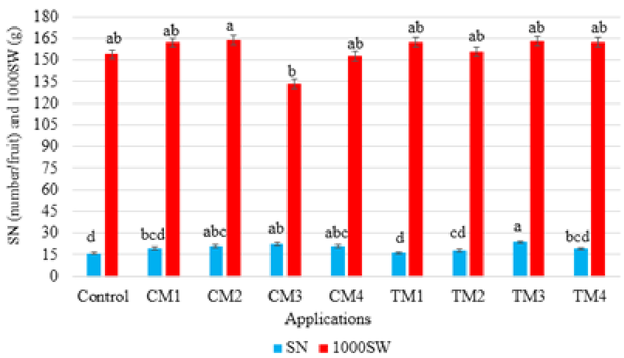

Figure 7. SN and 1000 SW values of bitter melon grown under different poultry manures.
*SN: Seed number, 1000 SW: 1000 Seed weight, CM: Chicken manure, TM: Turkey manure, Means in the bar chart followed by different letters (a, b, c and d) are significantly ($p < 0.05$) different by least significant difference test.

In the research results, 1000 seed weight values were found to be statistically significant in PM applications (Fig. 7). The 1000 seed weight of bitter melon were found to be between 133.17 – 164.03 g. In this study, where the general mean of 1000 seed weight was 156.56 g, the highest 1000 grain weight value was obtained from TM2 application, and followed by CM3 (162.97 g) and CM4 (162.27 g) respectively. The lowest 1000 seed weight was obtained from TM3 (133.17 g), and this was followed by TM4 (152.8 g) application.

Among the chicken manure doses, it was determined that the CM3 (162.97 g) had a positive effect, while among the turkey manure doses, the TM2 (164.03 g) had a positive effect.

The number of seed values were found to be lower than Valyaie et al. (2021) (27 – 39.33 number), Yaldiz et al. (2014) (22 – 31.2 number) and Çamlıca and Yaldız (2019) (4 – 37 number). The differences can be linked to genotype, organic fertilizer application, different climatic conditions and cultural practices.

The 1000 seed weight values (133.17 – 164.03 g) were found to be lower than Valyaie et al. (2021) (168 – 216.16 g) and M Gölükçü et al. (2014) (183.20 g), and the values were partly similar with Resmi and Sreelathakumary (2016) (150 – 187.3 g) and Mehta et al. (2024) (137.90 – 269.30 g). These differences can be explained depending on the applications and doses, ecological condition, genotype besides growing conditions. Çamlıca et al. (2025) found that many factors, such as genotypic characteristics, environmental factors, and cultural processes, affect 1000 grain weight.

Correlation analysis

The relationships among the yield and yield properties should be known for the production of plant in breeding programs. Because, identification of correlations between the examined properties is a very important issue to obtain high plant production values. The pearson correlation analysis separate the direct or indirect impacts of the correlation values, and visualizes the relationship among the examined properties (Bhatt, 1973).

The pearson analysis was conducted to determine the relationship among the 12 morphological and yield values of bitter melon towards grown under different poultry manure applications. The results of the Pearson correlation coefficients with 'r' values were showed in Table 3. Totally, 28 correlations were determined among the examined properties, and 17 of among them highly significant correlations and 7 significant positive correlations were obtained. Four significant negative correlations were found for the properties.

A highly significant positive correlation ($r = 1^{**}$) was seen between FW (kg/ha) and FW (g/plant). Since these properties are structurally closely related, it may be assumed that the FW (kg/ha) was the main factors of the yield components, attributing to the greater occurence tendency of FW (g/plant). Similarly, with FW values, DW (kg/ha) value showed highly significant positive correlation ($r = 1^{**}$) with DW (g/plant).

In addition, highly positive significant correlations were determined between FW (kg/ha) and DW (kg/ha), DW (g/-plant), and it was also noted between FW (g/plant) DW (kg/ha), DW (g/plant) with $r = 0.998^{**}$.

The lowest highly significant positive correlations were found between 50% FT and FW (kg/ha), FW (g/plant). The highest positive correlations were found between 50% FT and DW (kg/ha), DW (g/plant). In addition, FD had the lowest positive correlations ($r = 0.673^{*}$) with FW (kg/ha) and FW (g/plant). It was noted that PH value was not positively or negatively correlated with any of the examined properties (Table 3).

The negative correlations were found between 1000SW and FW (kg/ha), FW (g/plant), DW (kg/ha), DW (g/plant).

The results of the correlation analysis showed that the examined properties had positive impacts as direct or indirect amongst themselves, except PH, FD and 1000SW. Khan et al. (2015) reported that yield per plant showed indirect positive effect via fruit diameter and fruit weight. The obtained results were found similar with the Khan et al. (2015).

Table 3. Correlation analysis results among ten important morphological and yield properties of bitter melon grown under different poultry manure applications.

Applications	FFST	PH	FS	FD	FFT	FW(kg/ha)	FW (g/plant)	DW (kg/ha)	DW (g/plant)	SN	1000SW
%50 FT	0.958**	0.274	0.802**	0.612	0.384	0.801**	0.801**	0.795*	0.795*	0.484	-0.509
FFST		0.018	0.763*	0.615	0.229	0.815**	0.815**	0.81**	0.81**	0.433	-0.65
PH			0.259	0.063	0.499	0.04	0.04	0.048	0.049	0.146	0.48
FS				0.771*	0.433	0.906**	0.906**	0.909**	0.91**	0.471	-0.531
FD					0.191	0.673*	0.673*	0.646	0.646	0.025	-0.586
FFT						0.305	0.305	0.317	0.318	0.694*	0.038
FW (kg/ha)							1**	0.998**	0.998**	0.502	-0.792*
FW (g/plant)								0.998**	0.998**	0.502	-0.792*
DW (kg/ha)									1**	0.533	-0.773*
DW (g/plant)										0.533	-0.772*
SN											-0.235

*: Significant at 5%, **: Significant at 1%, 50% FT: 50% flowering time, FFST: First fruit setting time, PH: Plant height, FS: Fruit size, FD: Fruit diameter, FFT: Fruit flesh thickness, FW(kg/ha): Fresh weight (kg/ha), FW (g/plant): Fresh weight (g/plant), DW (kg/ha): Dry weight (kg/ha), DW (g/plant): Dry weight (g/plant), SN: Seed number, 1000SW: 1000 seed weight

Principal Coordinat Analysis (PCA)

The obtained data according to examined properties were subjected to principal component analysis (PCA) to be able to assess the morphological and yield values of bitter melon growm under different poultry manure applications. The PCA analysis showed an important part of the variability constituted 78.9% of the total variation. The Fig. 8 showed that the PC1 and PC2 were in a relationship. The PC1 and PC2 principal components comprised 65.4% and 13.5% of the total variation, respectively. In the PC1, most of the examined properties as 50% FT, FFST, FD, FW (kg/ha), FW (g/plant), DW (kg/ha), DW (g/plant) and SN had the highest coefficents. In the PC2, PH, FFT and 1000SW had the highest coefficients. When the PCA graph of the examined properties used in the study is examined (Fig. 8), it is noted that the most of the examined properties are quite similar with each other, and not distributed in the graph. Similary, the applications (CM and TM) showed quite similar, except control applications.

PCA analysis results showed about 80% total variation. Studies conducted by Jatav et al. (2022) reported that the first six principal components explained 84.05% total variation, and Mehta et al. (2024) reported that the first two PCs revelaed 49% of total variation in bitter melon.

Heat map analysis

Morphological and yield properties are the strongest and final indicators of the effect of poultry manure applications for the plant production of bitter melon. So, different multivariate analysis should be conducted on these data in all applications × 12 examined properties evaluate the poultry manure reactions of the bitter melon and establish the range of manure application responses detectable grown under different poultry manure applications and their doses in bitter melon. According to heat map in Fig. 9, it is clearly visualized that FW (kg/ha) is more pronounced under diffrent

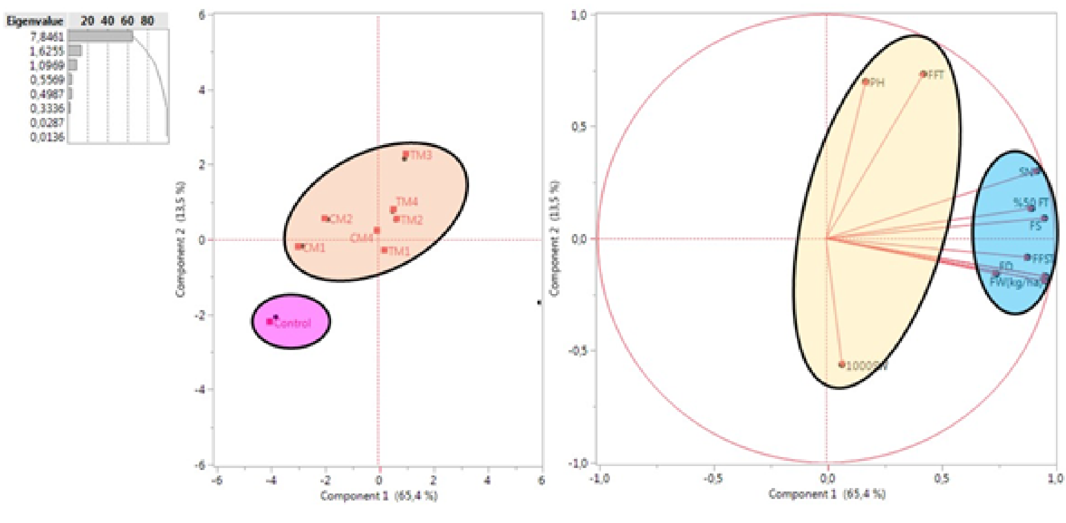

Figure 8. PCA analysis of the examined properties and applications.

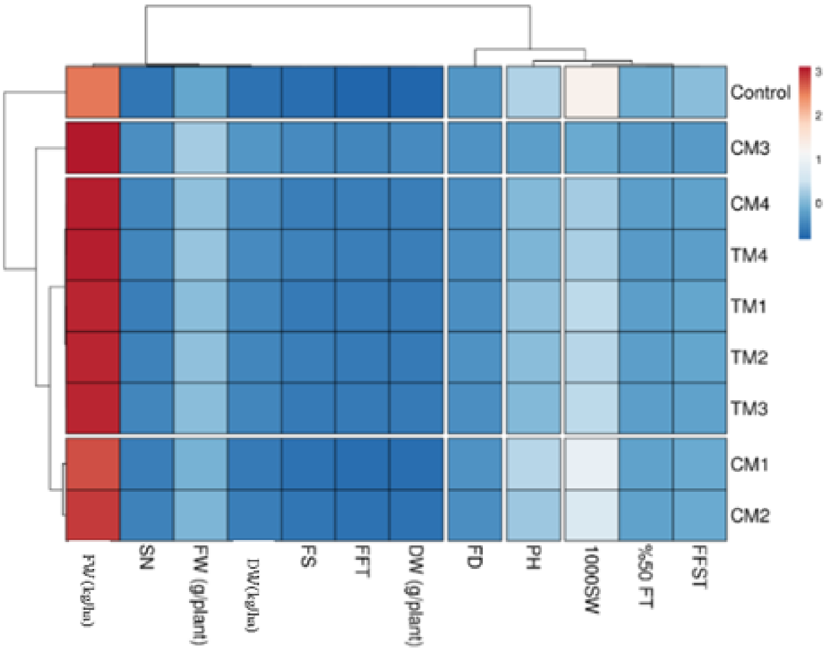

Figure 9. Heat map results according to examined properties.

applications. CM1, CM2 and control applications favoured towards DW (kg/ha), FS, FFT and DW (g/plant) whereas CM3 was seperated from other applications according to FD, 50% FT, FFST, PH values and 1000SW. All TM applications took place in the same group with CM4 application. As a result of heat map analysis, CM1 and CM2 applications can be suggested for the highest positive effect on the desired properties as FW (kg/ha), FW (g/plant), DW (kg/ha) and DW (g/plant) of the bitter melon for the organic agriculture (Fig. 9).

4. Conclusion

The present study shows the variability of the morphological and yield properties of bitter melon grown under different PM applications. According to our results, the application of CM3-4 (15 – 17.5 t/ha) and TM4 (17.5 t/ha) had a better effect on the fruit yield, which can be explained by the increase in the fruit number of plant. The correlation analysis showed positive effects among the examined properties, except PH and 1000SW properties. PCA anaysis revealed over than 80% total variation, and heat map analysis divided the FW (kg/ha) property from other properties. Generally, the results of the study indicated that the integrative application of high dose CM and TM could be suggested as a sustainable strategy for improving fruit yield, seed yield, morphology features of bitter melon. So, the findings of the study suggest that the application of CM and TM has promising effects on bitter melon fruit yield and can be considered as a suitable substitute for chemical fertilizers when growing bitter melon, a plant with increasing importance and demand.

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Authors contributions

G. Yaldiz; project administration, methodology: investigation, funding acquisition, conceptualization, visualization, validation, supervision, writing-original draft and writing-review & editing: M. Camlica; software, methodology, investigation, formal analysis, data curation, writing-review & editing and writing-original draft: D. Dasdemir; formal analysis, data collection and collected field data. The manuscript was evaluated by G. Yaldiz and M. Camlica and the final version of the manuscript was approved by all authors.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Conflict of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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