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Impact of Vermicompost Application on Soil Health and Yield of Eggplant (*Solanum melongena* L.)

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A FIELD experiment was conducted in a clayey soil to evaluate, the response of some physic-chemical properties of soil, some macro and micro-nutrients availability, plant yield, vegetative growth, some macro-micronutrients uptake and crop yield of eggplant (*Solanum melongena* L.) to the applications of different rates of vermicompost. Also, in this work, the effects of vermicompost on soil physic-chemical properties as well as the yield and vegetative growth of *Solanum melongena* L. were compared with the 100% mineral fertilizers and untreated soil (control). Vermicompost addition in three different dosages (10, 20, and 30 Mg ha-1. The soil chemical and physical properties, some macro and micronutrients availability, fruit weight, length, and diameter, as well as some macro and micronutrients uptake were measured after harvest. Vermicomposting significantly altered the properties of the soil and the growth of *Solanum melongena* L. The treatment 30 Mg ha^{-1}reflects the greatest increase in soil organic matter, available nitrogen, phosphorus, and potassium by 47.50%, 77.01%, 109.18% and 37.50%, respectively. According to the findings, the values of EC and pH were enhanced. Vermicompost as an organic manure enhanced the vegetative growth, production and qualities of eggplants in the of tested soil in usual conditions.

Keywords: organic fertilization; soil productivity; clayey soil; vegetable fruit.

1. Introduction

The applications of organic manure enrich organic matter content in soil and support plant growth in a comparable degree with mineral fertilizers. Vermicompost, an organic amendment produced through the bio-fermentation processes aided by earthworm digestive enzymes. Vermicompost manure enhances soil fertility and soil health through several methods (**Zhang *et al*., 2020; Ebrahimi *et al*.,2021: Serri *et al*., 2021)**. Soil health is tortuously linked to its biological activity, with soil enzymes playing a key role in maintaining biogeochemical cycles by facilitating organic matter decay and nutrient cycling (**Adetunji *et al*., 2017).** Among these, β-glucosidase catalyzes the break of glucosides, contributing to soil fertility and the carbon cycle, and serves as a vital indicator of soil health **(Partey *et al*., 2019).**

Organic manures have gained popularity recently as a useful technique for sustainable agriculture to satisfy crop nutrient needs **(Gwari *et al.,* 2014)**. This may be due to growing consumer awareness of the connection between food and health **(Riahi and Hdider, 2013)** and the growing expense of inorganic fertilisers combined with their incapacity to provide the soil with a healthy environment **(Oyedeji *et al.,* 2014).**

Solanum melongena L. shows many types of shapes, colors (green, white, yellow, purple and black pigmentation). It is an economically important crop in Africa and also cultivated in warm temperate regions of the Mediterranean. Eggplant fruits riche in many elements (Ca, K, Fe, and Mn), vitamins for healthy of human and it is low in calories, not only is used as cooking vegetable but as well as it has many medical uses, which is lower the blood cholesterol levels, regulating high blood pressure and suitable for diabetic and diet **(Ali *et al.,* 2019 : Palia *et al.,* 2021).** In recent years, the world faces excessive problematic concerned with either human health or the environmental contamination, as a result of the excessive application of mineral fertilizers. Concerning the nitrogen-excessive application, it could be incompletely attributed to the beginning of high

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yielding cultivars, while most of N- fertilizer is potential to lost by NO_3^- leaching to groundwater, which have a negative effect on human, animal and environment health **(Silpa and Vijayalakshmi 2022).**

Nowadays, there are improved interest in carbon-based materials recycling to recover soil fertility. Furthermore, the use of the natural organic trashes to soil had excessed drive and called organic agric., bio-agric. and clean agric. The combined application of the usual organic wastes and chemical fertilizers is well-thought-out as the ideal choice for dropping the preceding huge depletion of mineral fertilizers as well as keeping the status of fertility of soil and support to withstand crop production. The Modern Agricultural Approach lightens the dangerous impacts on developed plants in agricultural regions and the health of humans via toxic metals that persist in the ecosystem and are accumulated at various tropic levels of the food sequence. In addition to the biosphere's dynamic equilibrium **(Pinky and Vijayalakshmi 2022: Gnanamani and Vijayalakshmi 2024)**. The process by which earthworms *(Eisenia fetida)* consume organic materials and form what are known as companies is called vermicomposting. In a Rothamsted region including 25 different kinds of crops, fruits, or ornamentals residues, **Na *et al.,* 2022** reported that earthworm casts (EW) outdone compost or other potting blend modifications. It was proposed that the cast treatment's improved crop presentation resulted from improved soil structure, the presence on plant growth regulators, increased soil enzyme, and a larger population of microorganisms.

Phosphate-soluble bacteria, *Pseudomonas* sp., *Trichoderma*, nitrogen-fixing bacteria (*Azotobacter* and *Azosperillium, Nitrobacter*, and *Rhizobium*), macro (N, P, and K), and micro (Fe, Cu, Zn, and Mn) nutrients are all abundant in vermicompost, an organic manure that ranges from 10-2 to 10-6. **(Belliturk *et al.,* 2017)**. The present work was conducted to evaluate the impacts of various vermicomposting (as an organic manure) rates on some chemical and physical characteristics of soil, growth parameters, productivity and nutritious status of eggplant cultivated in clayey soil.

2. Materials and Methods

During the two consecutive summer seasons of 2021 and 2022, the current study was conducted on clayey soil at the Fayoum University Faculty of Agriculture farm in the Dar El Ramad district of El-Fayoum, Egypt. For treatment purposes, soil samples were taken from topsoil (0–30 cm) both before and after harvest. Table (1) provided values for a few of the studded topsoil's chemical and physical characteristics.

Table 1: some physico- chemical properties of the studded soil (before planting).

Soil characteristics	value	Soil characteristics	Value
Particle size distribution (%)		**Soluble cations (in soil paste extract, mmol L^{-1})**	
Sand	8.50	**Ca^{2+}**	9.70
Silt	39.10	**Mg^{2+}**	3.94
Clay	52.40	**Na^+**	24.65
Textural class	Clay	**K^+**	0.75
Bulk density (Mg m^{-3})	1.26	**CO_3^{2-}**	0.00
Total porosity (%)	48.00	**HCO_3^-**	12.20
Available water (%)	15.50	**Cl^-**	17.96
Hydraulic conductivity (cm h^{-1})	0.10	**SO_4^{2-}**	8.88
Field capacity (%)	41.70		
Wilting point (%)	26.20	**Available plant nutrients (mg kg^{-1})**	
Soil chemical characteristics			
pH in soil paste	7.98	**N**	40.45
$CaCO_3$ (%)	4.90	**P**	3.92
Organic matter (%)	0.95	**K**	278.17
EC_e (dS m^{-1})	3.92	**Fe**	5.04
Sodium adsorption ratio (SAR)	9.44	**Mn**	1.98
		Zn	0.76
		Cu	0.52

2.1 Experimental work

Eggplant seedlings were planted at the nursery on August 15, 2021, and August 5, 2022, as part of a field experiment conducted in the tested soil. The experimental treatments included five rows of 180 m² plots, each measuring 4 m by 75 cm in length and width.

1- Control (without additions).

2- 100% NPK mineral fertilizers (19:19:19) The fertilizers were added as urea (46% N) at the dose of 300 kg N ha^{-1}, superphosphate (15% P_2O_5) at the dose of 278 kg P_2O_5 ha^{-1} and potassium sulfate (48% K_2O) at the dose of 168 kg K_2O ha^{-1}. Phosphorus fertilizer was added during the soil preparation, while N and K fertilizers were added in two equal rates (4 and 8 weeks after transplanting). **Maghfoer *et al.*, (2014).**

3- 10 Mg $ha^{-1}$of Vermicompost =V1

4- 20 Mg $ha^{-1}$of Vermicompost =V2

5- 30 Mg $ha^{-1}$of Vermicompost =V3

The agronomic management techniques of tested plots were performed as normal, where vermicompost (as an organic amendment) was applied to tested plots at three rates (10, 20 and 30 Mg ha^{-1}) and vermicompost was blended with surface soil (0-30 cm depth) through processes of soil preparation.

The (SOMA) variety of eggplant seedlings were planted in each plot with 0.5m plant spacing. Using a completely randomized block design, all of the soil plots under study were watered using the local water supply. The usual cultivation managements were employed. Eggplant was harvested after 90 days of planting. According to **Black *et al.*, (1965)**, several chemical analyses of irrigation water were conducted and are displayed in table (2).

Table 2: Some chemical properties of the used irrigation water.

Properties	The Nile water
pH	7.320
EC_{iw} (dS m^{-1})	0.56
TDS (mg L^{-1})	358.40
Soluble ions (mmol L^{-1})	
Ca^{2+}	1.61
Mg^{2+}	1.19
Na^{+}	2.50
K^{+}	0.35
CO_3^{2-}	0.00
HCO_3^{-}	2.20
Cl^{-}	2.35
SO_4^{2-}	1.10
Sodium adsorption ratio (SAR)	2.13
*** degree of Irrigation water suitability**	C1S1

*Source: water salinity and sodicity classes (Ayers and Westcot (1985))

According to the methods outlined by **Soltanpour and Schwab (1977)** and **Page *et al.* (1982)**, certain chemical characteristics and nutrients of the added vermicompost (on dry weight basis) were measured; the results are shown in table (3).

Table 3. some chemical properties of used vermicompost.

Properties				Value		
Density (kgm^{-3})				798.45		
pH (1:10)				7.22		
Moisture (%)				8.35		
EC_e (dSm^{-1}, 1:10)				1.79		
O.M. (%)				34.75		
O. C. (%)				20.20		
C/N ratio				12.02		
Macro and micronutrient availability ($mgkg^{-1}$)						
N	**P**	**K**	**Fe**	**Mn**	**Zn**	**Cu**
768.00	273.00	587.00	194.00	72.00	51.00	35.00

2.2 Data of eggplant plant parameters

2.2.1 Vegetative growth and yield parameters

Four weeks soon after transplantation, random specimens about five plants were collected from every tested plot to measure various growth and yield factors, such as fruit diameter and length (cm), fruit weight (g) and total production (Mg ha^{-1}).

2.2.2 Nutrients uptake

Approximately 13 weeks following transplantation, five top leaves were removed from the stem of eight randomly selected plants. Cleaned using deionized water, then dried at 65 - 70 °C and digested according to **(Van-Schouwenberg, 1968)** for the determination of N, P and K **(Wilde *et al.*, 1985; A.O.A.C., 1990)** and Fe, Mn, Zn, and Cu **(Hesse, 1971).**

2.3 Statistical analyses

Data for different collected parameters were statistically analyzed by adopting analysis of variance (ANOVA) technique based on a completely randomized block design with three replications **(Steel and Torrie, 1997)**. The fertilization treatments were considered a fixed factor, while replications were considered a random factor. Duncan's multiple range test was used to identify treatment means that differed significantly at $p<0.05$ using INFOSTAT computer software (v.2020 statistical package, Córdoba University, Córdoba, Argentina) **(Di Rienzo *et al.*, 2016)**.

3. Results and Discussion

3.1. Impact of treatments on some soil chemical and physical properties' of the studied soil

Statistically a pronounced improve were detected in most of the tested soil chemical and physical properties (pH, EC_e OM, hydraulic conductivity, welting point, bulk density, field capacity and available water content) as given in Table (4). The values of both EC_e and bulk density were significantly decreased for the treatments of vermicompost application. While the values of organic matter and available water content were significantly increased due to the gradual application of organic manure. The findings were in agreement with those found by **(Xiang *et al.*, 2018)** vermicompost could rise carbon content and soil structural constancy better than other treatments**.** Data in Tables (4) and (5) declare that the beneficial impact of the applied vermicompost treatments were achieved as lowering soil pH, and in turn encouraging the nutrients availability, could be due to the formation of organometallic complexes containing chelated elements (such as Fe, Mn, Cu, and Zn). These findings were in covenant with many researchers, such as **Ashmaye *et al.*, (2008).** Commonly, the over- impact of vermicompost at rate of (30 t ha^{-1}), on nutrient availability contents in the soil could be referred to the slow release during the decomposition of vermicompost also, to reduce their possible lose by leaching **Mohammed (2004).** On the other hand, the role of vermicompost (as an organic manure) was markedly noticed for nutrients accessibility may be due to the excreted organic acids during microbial activity which improving the nutrient availability from added sources. These findings were consistent with **Chaoui *et al.*, (2003) and Al Ali *et al.*, (2019)**.

The superiority of vermicompost (30 Mg ha^{-1}) in the reduction of bulk density, EC_e, and pH values were converted in a pronounced increase of macro-micro nutrients availability and biological conditions that encourage the element uptake many nutrients (such as N, P, K, Cu, Zn, Fe, and Mn). the microorganisms activity in vermicompost decomposition coincide with organic acid excreted, that caused decreases of soil pH also, they have used to chelate some micronutrients (i.e., Cu, Zn, Fe, and Mn). These chelated metal cations serve as strategic storage in organometallic complexes that are available for plant uptake **(Mohmmed, 2004: Soraya *et al*., 2020).** The application of vermicompost significantly affected the available macro nutrient contents. The highest available N content was observed in the (30 Mg ha^{-1}) treatment, but significantly different from other treatments. Compared with the control, the available nitrogen, phosphorous and potassium values were increased by 77.01%.109.18% and 37.50% for vermicompost treatment 30t ha^{-1}. Also, the values of tested micro elements, (Fe, Mn, Zn and Cu) were gradual increased with vermicompost application treatments by 69.01%.123.7%.

Table 4. Impact of treatments on some soil chemical and physical properties' of the studied soil (the average of two seasons).

Treatment	ECe (dS m^{-1})	pH in soil paste.	Organic matter (%)	Bulk density (Mg m^{-3})	Hydraulic Conductivity (cm h^{-1})	Field capacity (%)	Available water (%)	Wilting point (%)
Negative control	3.91a	7.98	0.97d	1.33a	0.11d	42.02d	16.98e	25.04a
Positive control	3.77a	7.96	1.02d	1.30ab	0.12d	44.50c	20.47d	24.03b
10 Ver. (Mg ha^{-1})	3.23b	7.94	1.44c	1.24b	0.26b	46.43b	23.34c	23.09b
20 Ver. (Mg ha^{-1})	2.85c	7.91	1.67b	1.22b	0.33c	46.88b	25.11b	21.77c
30 Ver. (Mg ha^{-1})	2.78c	7.90	2.03a	1.11c	0.80a	47.14a	26.94a	20.20d

Table 5. Impact of treatments on available macro and micronutrients of the studied soil (average of two seasons).

	N	P	K	Fe	Mn	Zn	Cu
Treatments	**(mg kg^{-1})**						
Negative control	40.45e	3.92e	278.17c	5.04c	1.98e	0.76e	0.52e
Positive control	45.75d	4.96d	322.53bc	5.31c	2.21d	0.91d	0.89d
10	52.34c	5.70c	342.75ab	5.89b	3.59c	1.23c	1.17c
20	59.12b	7.28b	361.05ab	6.15b	3.95b	1.56b	1.25b
30	71.60a	8.2a	382.48a	8.54a	4.43a	1.87a	1.58a

Means with a common letter are not significantly different at ($p < 0.05$)

3.2. Response of plant characters and Plant nutrient contents to different applied treatments

3.2.1. Vegetative growth and yield characters

Data listed in Figure 1. showed that the realized favorable conditions of soil due to the different treatments, especially the dose of vermicompost (30 Mg ha^{-1}) were positively affected the tested growth and yield values of eggplants (such as fruit diameter and fruit length (cm), total production (Mg ha^{-1}) and fruit Weight (g). The highest dose of vermicompost treatment (30 Mg ha^{-1}) was statistically the superior all evaluated parameters under study dealing with vegetative growth, leaf macro elements, yield and fruit quality of eggplant. The results also showed that higher overall dry matter might be attributed to greater leaf area and quantity, which are associated with a faster photosynthesis process and the highest carbohydrates content. These findings aligned with those of **Ganeshnauth *et al.* (2018).** The enhanced parameters with treatment could be arranged in the following ascending order: (30 Mg ha^{-1}) > (20 Mg ha^{-1}) > (10 Mg ha^{-1}> 100% (N,P and K) > (control).

3.2.1. Plant nutrients uptake

Data of plant nutrients uptake (such as N, P, K, Zn, Cu, Mn, and Fe) by eggplant are listed in Table (6). The data showed a distinct significant increase as a result of applied vermicompost treatment (30 Mg ha-1) as compared with NPK mineral fertilizer and control treatment. (Gad El- Kareem et al., 2022) shown that, in comparison to mineral fertilization, organic manure treatments considerably raised the fruit contents of N, P, K, Ca, Mg, vitamin C, licobin, total soluble solids, and total sugars in both seasons. The favorable impact of vermicompost application (as organic manure) was performed due to reduction of soil pH that enhancing the availability and mobility of nutrients and ability to uptake by plant. Also, the vermicompost applications (enrichment in organic materials) improve the biological soil activity and soil-moisture conditions, that have a great potential for released elements as a warehouse in available forms for plant uptake. In addition, it has a favorable influence on the mobility of unrestricted plant nutrients as compared to the mineral fertilizer N, P or K treatment. This valuable influence may be clarified by many reasons, (i.e.,) cumulative the available micro and macro -nutrients through the breakdown process of the added manures, reduction nutrients fixation and formation of stable compounds of nutrients-humic materials provided from such materials and holding them in available compounds for long times (pourranjbari Saghaiesh et al., 2019: Shanmugam and Veeraputhran, 2001).

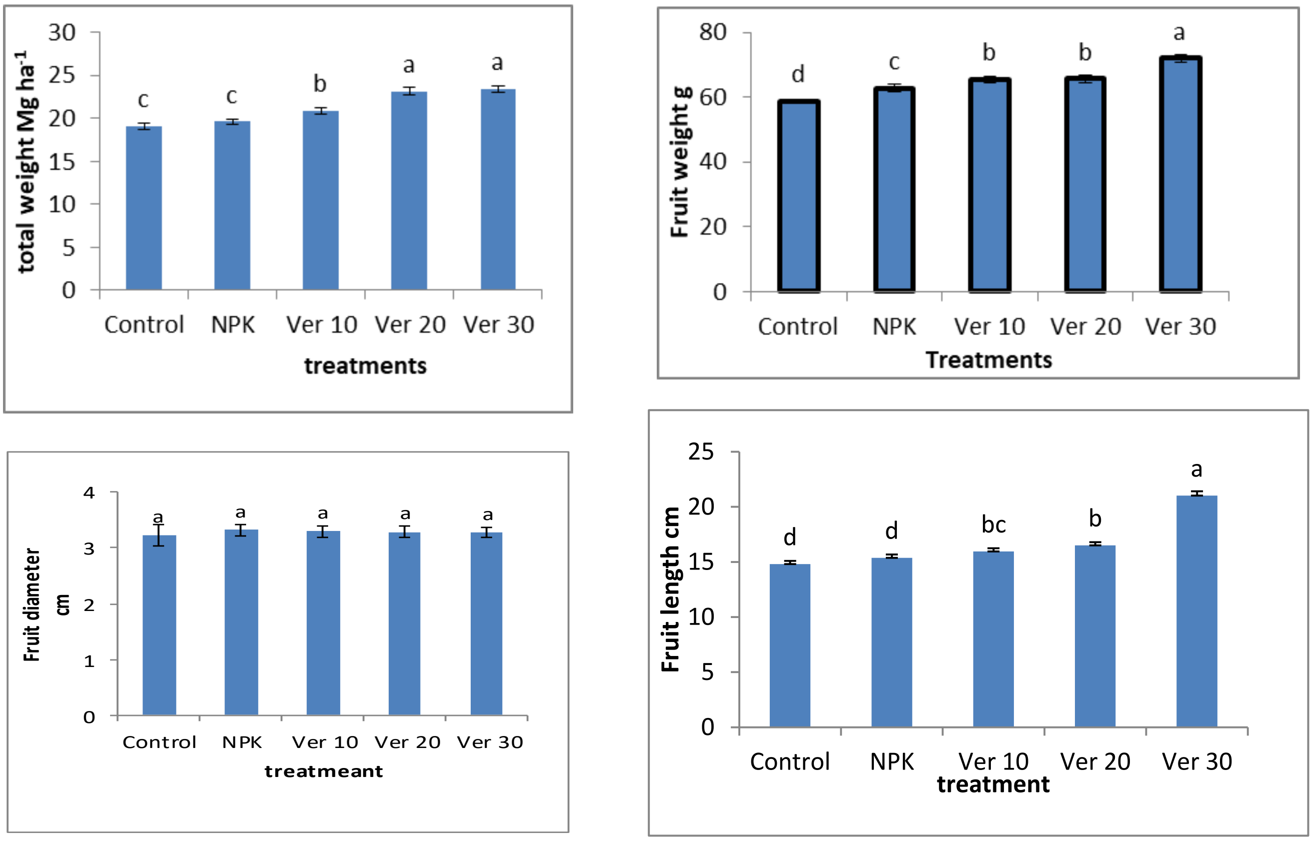

Fig. 1. Impact of the vermicompost application on the eggplant vegetative growth, yield, and macro-micronutrients uptake (the average of two seasons). Ver_{10}, Ver_{20}, Ver_{30} are applied vermicompost rates by 10, 20 and 30 Mg g ha^{-1} respectively.

Table 6. Impact of the vermicompost on macro and micronutrients uptake (plant for 2 seasons).

Treatments	N	P	K	Fe	Mn	Zn	Cu
	(mg kg^{-1})						
Negative control	2.58e	0.60d	1.20e	95.60	42.05e	30.78e	13.50e
Positive control	2.95d	0.68c	1.41d	125.10d	53.42d	40.08d	17.30d
10	3.35c	0.72bc	1.72c	140.80c	66.23c	47.16c	20.70c
20	3.89b	0.76b	1.86b	156.50b	73.65b	53.25b	27.70b
30	4.72a	0.87a	1.98a	183.80a	99.64a	70.30a	30.70a

Means with a common letter are not significantly different at ($p < 0.05$).

3.3 Economic assessment

Cost of cultivation for each treatment was worked by using market Price of all in puts used for growing crop on per hectare area basis. The net monetary return for each treatment was worked out by using the following formula (Ahirwar et al., 2023):

Net monetary return = Gross monetary return of treatment – Cost of cultivation of the same treatment.

Among the data of Table (7) Showed that treatment 30 Mg ha^{-1} Vermicompost received a significant maximum fruit yield of 23.44 30 Mg ha^{-1}, and net return of 194600 L.E ha^{-1} and benefit Cost of 157000 L.E ha^{-1}.
While the maximum net return was found with treatment 10 Mg ha^{-1} Vermicompost of 255600 L.E ha^{-1}.

Table 7. The economic impact of eggplant under different treatments.

Treatments	**Average cost and profitable impact (L.E ha^{-1})**		
	Total coast. (L.E ha^{-1})	**Total return (L.E ha^{-1})**	**Net return (L.E ha^{-1})**
Negative control	7000	95400	88400
Positive control	25000+7000=32000	98100	66100
10 (Mg ha-1)	57000	312600	255600
20 (Mg ha-1)	107000	347700	240700
30 (Mg ha-1)	157000	351600	194600

*Price EGP (Egyptian pound) calculated based on the average commercial (farm) price during the seasons of eggplant.
Price of non-organic eggplant = 5 L.E
Price of organic eggplant = 15 L.E
The average price of mineral fertilization, (19:19:19) = 450 L.E.
Average cost of agricultural operations such as plowing, labor, irrigation, eggplant seedlings and weeding = 7000 L.E.
The average price of 1 ton from vermicompost=5000 L.E.
From the economic evaluation, it was found that the highest net profit was in the 10 mega per hectare treatment, considering that the prices of organic vegetables are highest the price of eggplant.

Conclusions

Vermicompost made from a blend of animal and poultry manures was used, and this greatly enhanced the chemical and physical characteristics of the soil as well as the development and production of aubergine. When 30 Mg ha-1vermicompost was applied, the amount of available N increased by 77.01%, and the amount of organic matter, available P, K increased by 47.50%, 109.18%, 37.50, respectively, in comparison to the control. In the Fayoum Governorate of Egypt, applying 30 Mg ha-1 vermicompost could enhance soil and eggplant development.

Conflicts of interest
The authors declare that there is no conflict of interest.
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تأثير استخدام السماد الدودي على صحة التربة وإنتاجية الباذنجان (*Solanum melongena L.*)

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أجريت تجربة حقلية في تربة طينية لتقييم استجابة بعض الخصائص الفيزيائية والكيميائية للتربة، وتوفر بعض العناصر الغذائية الكبرى والصغرى، وإنتاجية النبات، والنمو الخضري، وامتصاص بعض العناصر الغذائية الكبرى والصغرى وإنتاجية المحصول للباذنجان (*Solanum melongena L.*) لتطبيقات معدلات مختلفة من السماد الدودي. كما تمت مقارنة تأثيرات السماد الدودي على الخصائص الفيزيائية والكيميائية للتربة وكذلك إنتاجية ونمو الباذنجان (*Solanum melongena L.*) بالأسمدة المعدنية بنسبة ١٠٠% والتربة غير المعالجة (الكنترول). إضافة السماد الدودي بثلاث جرعات مختلفة (١٠ و٢٠ و٣٠ طن/هكتار). وتم قياس الخواص الكيميائية والفيزيائية للتربة، وتوفر بعض العناصر الغذائية الكبرى والصغرى، ووزن الثمار وطولها وقطرها، وكذلك امتصاص بعض العناصر الغذائية الكبرى والصغرى بعد الحصاد. وقد أدى التسميد الدودي إلى تغيير كبير في خصائص التربة ونمو الباذنجان. وتعكس المعاملة ٣٠ طن/هكتار أكبر زيادة في المادة العضوية في التربة والنيتروجين المتاح والفوسفور والبوتاسيوم بنسبة ٤٧.٥٠% و٧٧.٠١% و١٠٩.١٨% و٣٧.٥٠% على التوالي. ووفقًا للنتائج، تم تحسين قيم التوصيل الكهربائي والرقم الهيدروجيني. وقد عزز التسميد الدودي كسماد عضوي النمو الخضري والإنتاجية وجودة الباذنجان في التربة المختبرة في الظروف المعتادة.

الكلمات المفتاحية: التسميد العضوي، إنتاجية التربة، التربة الطينية، محصول الخضر.