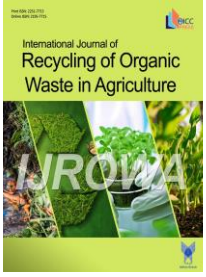

Int. J. Recycl. Org. Waste Agric., 2026; 15(3): 350-359

International Journal of Recycling of Organic Waste in Agriculture (IJROWA)

https://doi.org/10.57647/ijrowa.2026.1503.29

Research Article

Effect of Vermicompost on Growth Performance of Okra (*Abelmoschus esculentus*)

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Article History:

Received:
04 December 2024
Revised:
24 December 2024
Accepted:
22 April 2026
Published in Issue:
30 September 2026

Abstract

Purpose: Vermicompost is one of the alternative nutrient sources for crop plants as an organic amendment. This study evaluated the effect of vermicompost on the growth and performance of Okra (*Abelmoschus esculentus*).

Method: A Randomized Complete Block Design with eleven treatments were applied to 5 kg of processed soil. Treatments consisted of three levels of vermicompost (50 g, 100 g, and 150 g) alone and combined with two levels of urea (2 g, 4 g), including positive (8 g urea only) and negative (soil only) controls. Treatment codes were: T1-T3: VC alone, T4-T6: 4 g urea + VC, T7-T9: 2 g urea + VC, T10: 8 g urea (positive), and T11: 5 kg soil (negative control). Each treatment had five replicates and was applied during transplanting, three, and five weeks after transplanting. Growth and yield parameters were recorded from 10 to 70 Days after planting and analyzed using Minitab 15.

Results: The combination of 2 g urea with 150 g VC (T9) showed significantly higher performance in most of the growth and yield parameters (mean values of plant height: 54.8±4.76 cm, stem circumference: 2.84±0.09 cm, number and length of pods: 7±2.0 and 17.8±1.4 cm, and fresh and dry weight:128.4±8.3 g and 22.72±1.23 g). Plants treated with 100 g VC alone (T2) took a minimum day for flowering (43 days).

Conclusion: Vermicompost supplemented with a lesser amount of urea (T9: 2 g urea with 150 g VC) enhanced the growth and yield of okra, promoting environmentally friendly agricultural practices.

Keywords: Growth performance, Okra (*Abelmoschus esculentus*), Organic fertilizer, Vermicompost

Cite this article: Krishanthiny, R., Kannangara, S. & Mathiventhan, T., (2026). Effect of Vermicompost on Growth Performance of Okra (*Abelmoschus esculentus*), *International Journal of Recycling of Organic Waste in Agriculture,* 15(3), 350-359.
https://doi.org/10.57647/ijrowa.2026.1503.29

1. Introduction

The effective usage of biological fertilizers and the reduction of inorganic fertilizers can improve plant growth and soil fertility in the natural ecosystem (Cornelio & Laines, 2017). It is often recognized that organic wastes should be used as resources rather than throughout or left in the environment at much higher cost for corrections (Ebrahimi et al., 2021; Najarian & Souri, 2020). Vermicompost (VC) is one of the organic fertilizers that has recently become more prevalent in organic waste management. Vermicompost is derived through the biological breakdown of organic wastes by earthworms at a faster rate (Ansari & Ismail, 2012). One of the attractive elements of vermicompost consumption is its positive effect on the environment compared with the application of synthetic fertilizers and other forms of organic wastes (Ebrahimi et al., 2021).

Vermicompost comprises C, H, and O and nutrients such as NO_3, PO_4, Ca, K, Mg, S, and micronutrients, which exhibit similar effects to those of inorganic fertilizers on plant growth and yield (Singh et al., 2008). Vermicompost holds nutrients for a long time, whereas conventional compost fails to give the essential amount of macro and micronutrients, particularly the critical NPK, to plants promptly (Sinha et al., 2009).

Vermicompost plays a major role in improving the growth and yield of different field crops, including vegetables, flowers, and fruit crops (Gutierrez-Miceli et al., 2007). Okra (*Abelmoschus esculentus*) is a commercially important vegetable crop that grows in tropical and sub-tropical regions, and one of the most extensively known species belongs to the Malvaceae family.

The okra being a short-duration vegetable crop, its growth, yield, and quality are largely influenced by the availability of nutrients, thus depending on the application of fertilizers in general.

There are related experiments carried out to assess the comparative effect of vermicompost and chemical fertilizer on the growth and yield of okra, brinjal, and tomato plants in different countries (Sinha et al., 2009), but few studies have been reported in Sri Lanka on evaluating the effect of vermicompost on crop plants. In the meantime, vermicompost is less popular as a waste management practice in Sri Lanka.

Considering the above facts, the present study aimed to evaluate the effectiveness of the application of vermicompost on the growth performance of *Abelmoschus esculentus* (okra) and to compare the combined effects of vermicompost and inorganic fertilizer (urea) and inorganic fertilizer alone (urea) on the growth performance of okra.

Moreover, the present research component will contribute significantly to waste management practices in Sri Lanka and reduce the use of inorganic fertilizers in the agricultural sector in the future.

2. Materials and method

2.1. Experimental design and treatment application

The experiment was conducted in the experimental field of Eastern University, Batticaloa, Sri Lanka, for a period of three months.

The Randomized Complete Block Design (RCBD) with eleven treatments (3 levels of vermicomposting only and 2 levels of urea, each level combined with different levels of VC (Table 1), was used. Urea of 8 g was used as a positive control (optimum urea level for okra: 8 g/plant/3 applications in a lifetime (24 g/plant)- Department of Agriculture, Sri Lanka).

In all the treatments, the soil level (5 kg) was maintained uniformly as a planting medium. Polypots (30 cm x 40 cm) were used as an experimental unit. Each treatment was replicated five times.

A total of 55 experimental units were used. VC was obtained from the Model Farm, Jaffna, Sri Lanka. Okra seeds (*Abelmoschus esculentus*), with more than 75% germination rate, were obtained from the Government Seeds and Planting Material Production Division, Department of Agriculture, Karadiyanaru, Batticaloa, Sri Lanka.

Table 1. Treatment structure

Treatment code	Vermicompost (g/plant)	Urea (g/plant)	Soil (kg)	Description
T1	50	-	5	Vermicompost only
T2	100	-	5	Vermicompost only
T3	150	-	5	Vermicompost only
T4	50	4	5	Vermicompost + urea
T5	100	4	5	Vermicompost + urea
T6	150	4	5	Vermicompost + urea
T7	50	2	5	Vermicompost + urea
T8	100	2	5	Vermicompost + urea
T9	150	2	5	Vermicompost + urea
T10 (PC)	-	8	5	Urea only
T11 (NC)	-	-	5	Soil only

VC – Vermicompost, PC – positive control, NC – negative control.

2.2. Potting method and transplanting

A bulk sample of topsoil was collected from the surface layer (0-15 cm) of the field area of Eastern University, Sri Lanka, and processed, air dried, and sieved by using a 2 mm mesh sieve, for homogeneity. Five kilograms of the processed soil sample were used as the planting medium for each treatment (Table 1), placing them in labelled poly pots and arranging them according to the experimental layout.
Meantime, okra seeds were soaked overnight in water. The soaked seeds were planted at a space of 5 cm, at a depth of 3 cm in a seedbed, containing garden soil. One week after germination, the healthy seedlings (two-leaf stage) were selected for transplanting. One plant per pot was maintained, with a total of 11 treatments and 5 replicates per treatment, resulting in 55 pots in total.
Throughout the experimental period, plants were watered manually once a day and uniformly. Plants were kept weed-free until the final harvest by manual weeding.

2.3. Treatment application

Treatment applications were performed three times in accordance with the methodology of Ansari & Sukhraj (2010): at the time of seedlings transplanting, three weeks post transplanting, and five weeks post transplanting (before flowering).

2.4. Physicochemical analysis of vermicompost

The quality of the VC was assessed by determining the moisture content, nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Iron (Fe), Zinc (Zn), Copper (Cu) and Manganese (Mn) using standard methods as indicated in Table 2. pH and EC were measured according to Monedero et al (2001).

Table 2. Methods used to analyse moisture content and mineral components of VC

Test	Measurement unit	SLS (Sri Lanka Standard)
Moisture	dry basis (% by mass)	SLS 645 Part 2: 1984
Total Nitrogen (as N)	dry basis (% by mass)	SLS 645 Part 1: 2009 AOAC 892.01
Total Phosphorus (as P_2O_5)	dry basis (% by mass)	SLS 645 Part 5: 1985
Total Potassium (as K_2O)	on a dry basis (% by mass)	SLS 645 Part 4: 1989
Calcium (as Ca)	% by mass	
Magnesium (as Mg)	on a dry basis (% by mass)	
Iron (as Fe)	% by mass	Microwave digestion/ Detection by Inductively coupled plasma-mass Spectrometer (ICP-MS).
Zinc (as Zn)	mg/kg	
Copper (as Cu)	mg/kg	
Manganese (as Mn)	mg/kg	

2.5. Crop parameters

Data collection was carried out for two months after transplanting till the final harvest. For one treatment, 5 plants were used. Plant height, stem circumference, and number of leaves per plant were recorded every 10-day interval. Stem circumference was measured using a vernier caliper with 0.01 mm precision. Time for flower on-set and the number of flowers per plant were recorded every 2-day interval. The number of pods per plant, weight, and length of the pod, and number of seeds per pod were recorded at maturity. The fresh weight of root, shoot, and leaf were measured at the final harvest by using the digital balance (Kern and Sohn GmbH, WF 1404513, Germany). Dry weights of root, shoot, and leaf was measured after oven-drying at 70 °C until a constant weight was obtained. Root volume was measured by using the water displacement method adopted by Harrington et al (1994). Plants were closely monitored for the presence of any diseases throughout the study period.

2.6. Statistical analysis

All data were given as mean and standard deviation. The data was analysed statistically by one-way Analysis of Variance (ANOVA) at 0.05 levels using Minitab 15.

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3. Results and discussion

3.1. Physiochemical properties of vermicompost

Vermicompost was produced from locally available organic materials, including cow dung, Gliricidia leaves, and municipal organic waste, using the earthworm species *Eisenia fetida* and *Eudrilus eugeniae*. The levels of chemical properties of VC are given in Table 3. As estimated in the present study, moisture content, EC, and pH of the VC were 49.6%, 1.4 mS/cm, and 6.5, respectively (Table 3).

The value of pH was around 7, indicating that it is in the neutral range, which allows nutrients to be readily available to the plants. Studies carried out by Perera & Nanthakumaran (2015) also showed higher values of moisture content and EC and lower values of pH in VC.

The present study revealed the presence of different essential nutrient elements (N, P, K, Ca, Mg, S, Fe, Zn, Cu, Mn) in the tested VC that are important for plant growth and development. It is also highlighted that the presence of macro element phosphorus (P) in higher amounts compared to other elements influences plant growth and yield.

VC showed higher levels of chemical properties, except for nitrogen and iron, when comparing the previous study of the same by Oroka .(2016). Similarly, N, P, and K in VC also showed higher values when comparing the results obtained from a previous study carried out by Perera & Nanthakumaran (2015).

The changes in the compositions of N, P, and K in these two different VCs may be due to the difference in the plant-based material consumed by different earthworms (Naiji & Souri, 2018).

Table 3. Physicochemical properties of vermicompost

Physiochemical Parameters of vermicompost	Results
Moisture	49.6±0.1%
pH	6.5±0.1
EC	1.4±0.1 mS/cm
Total Nitrogen (as N)	1.4±0.1%
Total Phosphorus (as P_2O_5)	1.8±0.1%
Total Potassium (as K_2O)	0.7±0.1%
Calcium (as Ca)	1.5±0.1%
Magnesium (as Mg)	0.6±0.1%
Iron (as Fe)	0.6±0.1%
Zinc (as Zn)	99.0±0.3 mg/kg
Copper (as Cu)	16.0±1.0 mg/kg
Manganese (as Mn)	406.0±1.7 mg/kg

Data presented as mean values of three samples

3.2. Crop parameters

Plant growth can be visualized in terms of an increase in length or plant height, stem diameter, increase in cell numbers, increase in fresh weight and dry weight, increase in leaf area, and leaf weight.

3.2.1. *Plant height*

Plant height ranged between 11.78±1.15 cm (in T5) and 54.8±4.76 cm (in T9) within a period of 70 DAP. Different treatments showed significant changes in plant height with time among the treatments, except for 20 DAP (Table 4). The maximum height was recorded in treatment T9 at 30, 60, and 70 DAP, such as 30.9, 52.4, and 54.8 cm, respectively.

Treatment 8 (urea 2 g, VC 100 g) showed higher values at 10 and 20 DAP, whereas T2 (VC 100 g only) treated plants showed higher values at 40 and 50 DAP.

The control (positive and negative) treatments showed significantly lower plant height compared to the other treatments, except for 20 DAP.

Table 4. The height of okra at different periods

Treatments	Days After Planting (DAP)						
	10	20	30	40	50	60	70
T1	13.44±1.18[ab]	19.20±1.25[a]	29.40±1.14[ab]	33.40±3.58[abc]	40.80±2.95[abc]	44.40±1.82[bc]	45.40± 1.82[bc]
T2	12.98±1.59[ab]	18.70±1.30[a]	29.90±2.75[ab]	39.00±7.62[a]	46.20±5.93[a]	48.80±4.38[abc]	50.80±3.96[abc]
T3	12.26±1.97[ab]	17.04±2.50[a]	29.50±0.50[ab]	36.20±3.35[ab]	45.40±3.71[a]	52.20±4.92[a]	53.80±5.63[a]
T4	12.38±1.69[ab]	19.30±0.96[a]	29.30±3.60[ab]	34.80±7.19[abc]	43.20±7.40[ab]	49.60±5.59[ab]	51.40±5.50[a]
T5	11.78±1.15[b]	17.66±2.90[a]	28.00±1.87[abc]	33.40±4.22[abc]	42.80±5.63[ab]	50.40±6.58[a]	52.20±6.18[a]
T6	13.46±1.48[ab]	18.90±0.55[a]	28.20±1.48[abc]	33.20±4.44[abc]	42.20±4.38[ab]	50.20±2.77[a]	52.60±4.56[a]
T7	12.94±1.50[ab]	18.40±3.49[a]	30.80±2.68[a]	37.20±5.02[ab]	46.00±6.44[a]	50.00±5.52[ab]	51.60±5.13[a]
T8	14.02±0.29[a]	19.64±1.71[a]	29.20±3.35[ab]	32.00±4.64[bc]	43.60±5.94[ab]	50.20±3.27[a]	51.20±3.27[ab]
T9	13.18±1.63[ab]	18.70±2.51[a]	30.90±2.70[a]	35.60±5.13[abc]	45.60±5.77[a]	52.40±4.51[a]	54.80±4.76[a]
T10	12.06±1.37[b]	17.40±1.78[a]	27.00±1.73[bc]	31.40±2.30[bc]	38.00±2.92[bc]	43.20±5.40[c]	45.20±5.97[c]
T11	11.88±1.16[b]	17.52±1.71[a]	26.00±1.87[c]	30.00±2.12[c]	34.60±1.14[c]	35.80±1.48[d]	36.20±1.48[d]

The period is indicated as the Days After Planting (DAP). T1- VC (50 g); T2- VC (100 g); T3- VC (150 g); T4- Urea (4 g) + VC (50 g); T5- Urea (4 g) + VC (100 g); T6- Urea (4 g) + VC (150 g); T7- Urea (2 g) + VC (50 g); T8- Urea (2 g) +VC (100 g); T9- Urea (2 g) + VC (150 g); T10- Urea (8 g) positive control; T11-Only soil (Negative control). Analysis was performed at a 5% significance level. Values are means of five replicates. Means having the same letter indicates no significant difference (column-wise).

3.2.2. *Stem circumference*

Stem circumference ranged from 0.52±0.04 cm (in T11) to 2.84±0.09 cm (in T9) within a period of 70 DAP. The maximum values were recorded in treatment T9 at 30-70 DAP, such as 2.14 cm, 2.24 cm, 2.7 cm, 2.76 cm, and 2.84 cm, respectively (Table 5).

Different treatments showed significant changes in stem circumference with time (DAP). The control (positive and negative) showed significantly the least performance (positive control: 0.62-2.16 cm and negative control: 0.52-1.58 cm) compared to the other treatments, but among the controls negative control (T11) showed significantly the least performance (0.52-1.58 cm) than the positive control (T10). However, T9-treated plants showed significantly higher stem circumference with time, except for 10 and 20 DAP.

3.2.3. *Number of leaves*

The number of leaves ranged from 3±0.00 (in T1, T3, and T11) to 15.8±1.10 (in T8) within a period of 70 DAP. The maximum values were recorded in the treatment T8 at 10,60 and 70 DAP, such as 3.6, 15, and 15.8, respectively (Table 6). Treatment 7 (urea 2 g, VC 50 g) showed more leaves in this regard at 40 and 50 DAP, whereas T9 (urea 4 g, VC 150 g) treated plants showed more leaves at 30 DAP, and T5 (urea 2 g, VC 100 g) showed more leaves at 20 DAP.

The controls (positive and negative) had significant changes in the number of leaves (3.6-12.4 and 3- 9.8 respectively) compared to the other treatments. Among that, negative control (T11) showed significantly lesser number of leaves (3- 9.8) than other treatments. Most of the time, the plants treated with urea with VC (T4-T9) showed more leaves than VC alone (T1-T3) and the control (T10, T11).

Kumar et al. (2011) reported that the use of organic fertilizers such as vermicompost, instead of chemical fertilizers, significantly increased the number of leaves in the *stevia* plant, whereas Perera & Nanthakumaran (2015) reported that the plants treated with chemical fertilizer showed the maximum number of leaves.

However, in the case of our study, plants treated with a combination of urea and VC showed a better effect on the number of leaves. The mean comparison indicated that the negative control (T11) showed a negative impact on growth.

Table 5. The Stem circumference of okra at different periods

Treatments	Days After Planting (DAP)						
	10	20	30	40	50	60	70
T1	0.64±0.09^{ab}	1.08±0.20^{abc}	1.66±0.25^{bcde}	1.96±0.25^{cde}	2.38±0.27^{c}	2.44±0.13^{d}	2.46±0.15^{d}
T2	0.64±0.09^{ab}	1.08±0.20^{abc}	2.02±0.27^{ab}	2.32±0.30^{abc}	2.46b±0.15^{c}	2.46±0.15^{cd}	2.50±0.21^{cd}
T3	0.60±0^{ab}	1.10±0.12^{abc}	1.88±0.20^{abcd}	2.20±0.19^{abcd}	2.50±0.00^{abc}	2.56±0.13^{bcd}	2.56±0.13^{bcd}
T4	0.64±0.09^{ab}	1.12±0.04^{abc}	1.66±0.39^{bcde}	2.02±0.33^{bcde}	2.38±0.16^{c}	2.62±0.16^{abc}	2.72±0.22^{abc}
T5	0.68±0.11^{a}	1.02±0.18^{bc}	1.52±0.35^{de}	1.90±0.30^{de}	2.38±0.27^{c}	2.56±0.13^{bcd}	2.72±0.22^{abc}
T6	0.68±0.11^{a}	1.02±0.11^{bc}	1.60±0.30^{cde}	2.04±0.43^{bcde}	2.44±0.13^{bc}	2.56±0.13^{bcd}	2.72±0.22^{abc}
T7	0.66±0.13^{a}	1.16±0.26^{abc}	2.00±0.43^{ab}	2.36±0.34^{ab}	2.62±0.28^{ab}	2.68±0.18^{ab}	2.72±0.22^{abc}
T8	0.72±0.11^{a}	1.28±0.20^{a}	1.96±0.25^{abc}	2.24±0.23^{abcd}	2.62±0.16^{ab}	2.68±0.16^{ab}	2.78±0.18^{ab}
T9	0.68±0.16^{a}	1.20±0.14^{ab}	2.14±0.49^{a}	2.44±0.54^{a}	2.70±0.19^{a}	2.76±0.15^{a}	2.84±0.09^{a}
T10	0.62±0.11^{ab}	0.98±0.11^{cd}	1.30±0.07^{ef}	1.68±0.16^{e}	1.84±0.18^{d}	2.02±0.11^{e}	2.16±0.15^{e}
T11	0.52±0.04^{b}	0.78±0.11^{d}	1.04±0.19^{f}	1.28±0.11^{f}	1.44±0.05^{e}	1.54±0.05^{f}	1.58±0.04^{f}

The period is indicated as the Days After Planting (DAP). T1- VC (50 g); T2- VC (100 g); T3- VC (150 g); T4- Urea (4 g) + VC (50 g); T5- Urea (4 g) + VC (100 g); T6- Urea (4 g) + VC (150 g); T7- Urea (2 g) + VC (50 g); T8- Urea (2 g) + VC (100 g); T9- Urea (2 g) + VC (150 g); T10- Urea (8 g) positive control; T11-Only soil (Negative control). Analysis was performed at a 5% significance level. Values are means of five replicates. Means having the same letter indicates no significant difference column-wise.

Table 6. Number of leaves of okra at different periods

Treatments	Days After Planting (DAP)						
	10	20	30	40	50	60	70
T1	3.0±0.00^{a}	5.2±0.45^{ab}	8.4±0.89^{ab}	9.6±1.14^{ab}	11.2±0.84^{c}	12.6±0.89^{bc}	13.4±1.14^{cd}
T2	3.4±0.55^{a}	5.2±0.45^{ab}	8.8±0.84^{a}	9.8±0.84^{ab}	12.0±0.71^{bc}	12.4±0.89^{bc}	12.8±0.84^{d}
T3	3.0±0.00^{a}	5.0±0.71^{b}	8.8±0.45^{a}	9.8±0.45^{ab}	13.0±1.87^{abc}	13.6±1.67^{ab}	13.8±1.64^{bcd}
T4	3.6±0.55^{a}	5.8±0.84^{ab}	9.0±1.41^{a}	10.4±1.14^{a}	12.8±2.59^{abc}	14.2±1.92^{a}	15.0±1.87^{abc}
T5	3.2±0.84^{a}	6.0±1.00^{a}	8.4±1.14^{ab}	10.0±1.87^{a}	13.0±2.35^{abc}	14.8±1.64^{a}	15.2±1.64^{ab}
T6	3.6±0.55^{a}	5.6±0.55^{ab}	8.6±1.34^{ab}	10.4±1.82^{a}	13.6±1.82^{ab}	14.6±1.34^{a}	15.0±1.22^{abc}
T7	3.2±0.55^{a}	5.8±0.84^{ab}	9.2±0.84^{a}	11.0±1.22^{a}	14.2±0.84^{a}	14.4±1.14^{a}	15.0±0.71^{abc}
T8	3.6±0.55^{a}	5.6±0.55^{ab}	8.8±1.10^{a}	9.8±1.10^{ab}	14.0±1.00^{a}	15.0±0.71^{a}	15.8±1.10^{a}
T9	3.6±0.55^{a}	5.8±0.45^{ab}	9.6±1.14^{a}	10.0±2.00^{a}	13.6±1.52^{ab}	14.8±0.84^{a}	15.6±0.55^{a}
T10	3.6±0.55^{a}	5.6±0.55^{ab}	7.4±0.55^{b}	8.2±2.00^{bc}	11.2±1.48^{c}	12.0±1.00^{c}	12.4±1.52^{d}
T11	3.0±0.00^{a}	5.0±0.00^{b}	7.4±0.55^{b}	7.6±0.55^{c}	9.0±0.71^{d}	9.4±0.89^{d}	9.8±1.30^{e}

The period is indicated as the Days After Planting (DAP). T1- VC (50 g); T2- VC (100 g); T3- VC (150 g); T4- Urea (4 g) + VC (50 g); T5- Urea (4 g) + VC (100 g); T6- Urea (4 g) + VC (150 g); T7- Urea (2 g) + VC (50 g); T8- Urea (2 g) + VC (100 g); T9- Urea (2 g) + VC (150 g); T10- Urea (8 g) positive control; T11-Only soil (Negative control). Analysis was performed at a 5% significance level. Values are means of five replicates. Means having the same letter indicates no significant difference column-wise.

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3.2.4. *Yield parameters*

The average number of days taken for flowering per plant observed was minimal (43 days) for plants treated with T2 (100 g of VC). These results indicated the fact that the okra pods in the T2 treatment could be harvested earlier. However, a higher number of yields (7 pods) was observed in T9 with time up to DAP 70. Table 7 clearly shows that all the flowers developed fruits except the negative control (T11), where some flowers dropped off from the plant in T11. The average number of fruits per plant observed was the maximum (7**)** for plants treated with T9, followed by T6 (6.8**)** and T8 (6.2), respectively. The average length of the pods at harvesting was maximum (17.78 cm) for plants treated with T9, followed by almost the same amount for T8 (17.6 cm) and T6 (17.58 cm). Meanwhile, the average number of seeds per plant was also high (50.4) in T9-treated plants, followed by T8 and T7. The weight of the fruits per plant measured during harvesting was maximum (20.36 g) for plants treated with T8, followed by almost the same amount for T6 (20.22 g) and T9 (20.1 g), respectively (Table 7). A combination of vermicompost and inorganic chemical fertilizer results in a maximum number of flowers and pods of okra plants (Das et al., 2014). The combination of urea and the vermicompost treatments (T4-T9) showed higher yields, among that T9 (150 g VC and 2 g urea) treated plants showed higher yield parameters such as number of flowers (7), number of fruits (7), fruit length per plants (17.78 cm), number of seeds per pod (50.4), root volume (11 ml), and fresh and dry weight of the plant (128.4 g and 22.72 g respectively) than other treated plants.

The visual comparisons based on the length of the fruit of okra fruits clearly showed that the plants treated with T9 and T8 have produced a better yield than other treatments (Figure 1).The fresh and dry weight of the okra crop was recorded as maximum in treatment T9, followed by T8, T6, T4, and T7, as shown in Table 8. The moisture held by the plant was found to be better in T9 in okra, as the vermicompost with urea was found to be effective among other treatments.

The root volume is also higher in T8 and T9, followed by T4, T5, T6, and T7

Table 7. Mean values of flower and yield parameters in different treatments.

Treatments	Days taken for first flower	No of flowers	No of fruits	Fruit Weight (g)	Fruit Length (cm)	No of seeds per pod
T1	48±1.3	3.2±1.1	3.2±1.1	13.3±1.5	13.7±1.0	29.85±1.6
T2	43±2.8	4.4±0.5	4.4±0.5	14.5±1.8	14.74±1.6	34.27±1.0
T3	45±2.1	5.6±1.14	5.6±1.14	18.46±4.1	16.14±2.4	40.25±1.8
T4	45±0.8	4.6±0.89	4.6±0.89	18.9±1.9	17.2±1.5	43.72±1.5
T5	48±1.3	5.2±0.84	5.2±0.84	19.32±2.7	17.1±1.9	41.55±1.9
T6	46±2.6	6.8±2.05	6.8±2.05	20.22±2.8	17.58±1.4	42.41±1.3
T7	46±1.3	5.6±0.55	5.6±0.55	19.44±2.7	17.04±1.9	46.41±0.8
T8	46±1.6	6.2±1.64	6.2±1.64	20.36±2.1	17.6±1.4	47.62±1.5
T9	46±1.9	7±2.0	7±2.0	20.1±2.6	17.78±1.4	50.4±1.0
T10	52±1.7	3.4±0.55	3.4±0.55	14.6±1.6	14.06±0.7	30.57±0.9
T11	55±3.2	2.6±0.89	1.8±0.84	10.86±1.7	11.04±0.9	26.14±0.5

Values represent the mean of five replicates (n=5)

Figure 1. Yield of okra in different treatments

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Table 8. Mean values of fresh and dry weight and root volume of okra plant

Treatments	Fresh Weight(g)			Root volume (ml)	Dry weight(g)		
	Leaf	Shoot	Root		Leaf	Shoot	Root
T1	46.4±1.7	50.4±1.5	12.8±0.8	8.2±0.84	5.08±0.31	9.9±0.39	2.82±0.26
T2	48.4±1.95	51.6±1.3	14±1	8.8±0.45	5±0.48	10.48±0.93	3.08±0.26
T3	49±1.58	53.2±2.28	14.4±1.14	9.4±0.55	5.32±0.29	10.9±0.87	3.18±0.34
T4	51±1.58	57.4±1.82	15.8±1.30	10±1	5.7±0.29	12.66±0.68	3.5±0.29
T5	48.4±3.21	55.4±1.67	15.4±1.14	10±0.71	5.04±0.65	11.82±0.77	3.48±0.33
T6	51.6±2.30	57.6±1.52	16.6±0.89	10.6±1.14	5.66±0.32	12.96±0.33	3.72±0.13
T7	50.8±1.79	57±2	15.8±0.84	10.4±0.55	5.46±0.24	12.84±0.36	3.5±0.16
T8	51.8±1.92	58.4±2.07	16.4±1.14	11±0.71	5.58±0.31	13.2±0.35	3.66±0.17
T9	53±3.87	58.6±3.65	16.8±0.84	11±1	5.82±0.54	13.12±0.56	3.78±0.13
T10	28±2.24	33±2.24	11.2±1.3	6±0.71	2.96±0.29	6.52±0.23	1.36±0.24
T11	16.8±1.3	20.2±1.64	6.4±0.55	4.4±0.55	1.32±0.16	2.96±0.27	0.72±0.08

Values represent mean ± standard deviation (n=5)

3.3. Qualitative (visual) observation of plant disease

Okra plants were often affected by various pests and diseases. In the present study, some kind of disease symptoms, such as fungal spread on the flower and light green to white squiggles on leaf surfaces were manifested only in the plants of the negative control (T11), and no such disease symptoms were observed in other ways treated plants at 70 DAP (Figure 2). Vermicompost, being free from pathogens and toxic compounds, enhances plant resistance to pests and diseases (Samaranayake & Wijekoon, 2010).

The findings of the present study were also supportive of this statement, as the VC and VC with urea-treated plants (T1-T10) did not show any symptoms of plant diseases. But the Okra plants in the T11 treatment (negative control) were affected by insects and diseases (Figure 2). Our observations were further in agreement with the findings of Deshmukh et al. (2010): "amendments of a combination of organic and inorganic sources of nutrients to crop plants might be helpful to obtain a good economic return with good soil health for the subsequent crop yield". Plants treated with vermicompost with urea (T4-T9) showed significantly higher growth and yield parameters than those of the plants treated with VC alone (T1-T3), except for the flower onset time.

Plants treated with VC alone gave a better yield than the controls (T10 and T11).

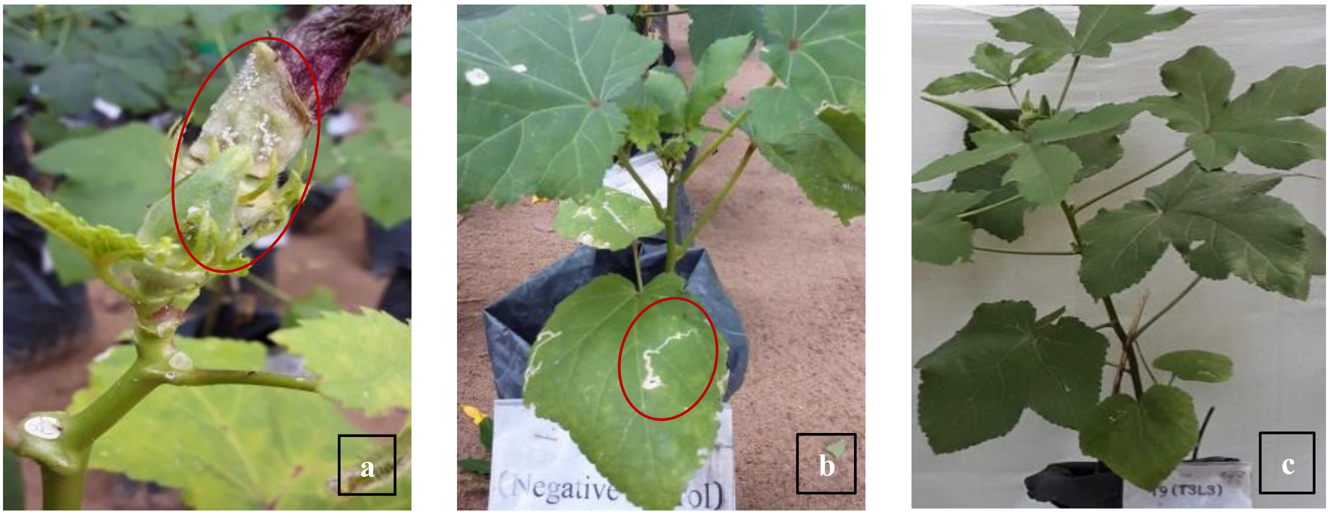

Figure 2. (a, b) Disease symptoms of Okra plants based on the qualitative observations at ,70 DAP in T11-treated plants. (c) Picture for non-diseased plant from the best treatment (T9)

Meanwhile, among the treatments T4-T9, treatment T9 showed the highest values in plant height (Table 4), stem circumference (Table 5), number of flowers, number of fruits, and fruit length (Figure 1), number of seeds per pod (Table 7), fresh and dry weight of the plant, and root volume (Table 8). The present study revealed that the T9-treated plants (150 g VC and 2 g Urea) showed higher growth parameters, including the yield, than the plants treated separately with different levels of fertilizer.

4. Conclusion

Okra plants treated with the T9 combination (150 g VC with 2 g Urea) exhibited significantly superior growth and yield parameters, including plant height, stem circumference, number and length of pods, fresh and dry weight of plant, compared with other treatments. The findings of the present investigation demonstrate that the application of vermicompost combined with lower levels of urea serves as an effective alternative fertilizer source for Okra (*Abelmoschus esculentus*) plants. This approach has the potential to reduce dependence on chemical fertilizers while maintaining or enhancing crop productivity. However, further research involving different crop species and diverse agroecological regions is recommended to validate and generalize these findings. Additionally, the large-scale production and utilization of vermicompost could contribute significantly to the sustainable management of organic waste and promote cost-effective and environmentally friendly agricultural practices in Sri Lanka.

Authors Contribution
Conceptualization and design of the work: R.K, T.M and S.K; Data collection, Data analysis, interpretation, original draft: R.K.; Supervision, guidance, and manuscript reviewing: T.M and S.K. All authors read and approved the final manuscript.

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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