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PERFORMANCE AND NUTRIENT CONTENT OF OKRA (*Abelmoschus esculentus* L. Moench) FRUITS AS INFLUENCED BY VERMICOMPOST, NITROGEN AND ZINC GROWN IN SOIL

Prity, N. N., M. Syed* and M. K. Rahman

Department of Soil, Water and Environment, University of Dhaka, Dhaka-1000, Bangladesh

*Corresponding author: mahmud-2015017365@swe.du.ac.bd

Abstract

This investigation aimed to assess the influence of soil-applied vermicompost, nitrogen and zinc on the vegetative growth parameters, yield, and mineral nutrient concentration of the fruits of okra (*Abelmoschus esculentus* L. Moench). The experiment was laid out in a Completely Randomized Design followed by three replications. Data were subjected to analysis of variance and mean values were compared using Tukey's Range Test at $p \leq 0.05$. Variation in mean values was compared among eight treatments: control (T_1), 6 ton ha^{-1} vermicompost (T_2), 60 kg ha^{-1} N (T_3), 2 kg ha^{-1} Zn (T_4), 6 ton ha^{-1} vermicompost + 60 kg ha^{-1} N (T_5), 60 kg ha^{-1} N + 2 kg ha^{-1} Zn (T_6), 6 ton ha^{-1} vermicompost + 2 kg ha^{-1} Zn (T_7), and 6 ton ha^{-1} vermicompost + 60 kg ha^{-1} N + 2 kg ha^{-1} Zn (T_8). The maximum growth performance and yield contributing properties of okra, *viz.* plant height (56 cm), leaf number (11 plant^{-1}), leaf area (14.5 cm^2), stem girth (3.5 cm), branch number (8 plant^{-1}), and fruit number (6.50 plant^{-1}), fruit diameter (5.50 cm), fruit length (13.50 cm), and weight of fresh (64.29 g) and dry plant materials (14.56 g), were found in T_5. The control T_1 performance showed reducing trends compared to other treatments. Although there was no significant difference with the application of vermicompost 6 t ha^{-1} + N 60 kg ha^{-1} + Zn 2 kg ha^{-1} (T_8), the treated pot in vermicompost with 6 t ha^{-1} + N 60 kg ha^{-1} (T_5) showed the best achievements of macro elements N (0.008%), P (6.70 ppm), K (0.08 cmol/kg), and S (18.22 ppm) of post-harvest soil compared to the control T_1. Mineral nutrients of fruits N-1.64%, P-0.27%, K-0.30%, S-0.10%, and Fe-0.02% and protein content 10.23% were found to be highest in the identical T_5 where Zn content was highest (0.28%) in T_8. This study showed that the treatment of vermicompost with 6 t ha^{-1} + N 60 kg ha^{-1} (T_5) contained and released quality nutrients is recommended for its overall best growth performance for okra.

Key words: Vermicompost; Nitrogen and zinc; Nutrient accumulation; Growth performance; Yield; Okra.

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench), a desired nutritious vegetable crop in Bangladesh, mainly originated in Asia and Africa (Thomson and Kelly 1979). This crop accommodates a large area under cultivation with substantial socio-economic potential. It is an annual shrub cultivated mainly within tropical and subtropical regions across the globe and represents a popular garden and farm crop. Globally, okra is known for its palatability and tender green fruits, which grow primarily during the summer and rainy seasons. It is a rich source of carbohydrates, amino acids, and vitamins which have multipurpose use like fresh or cooked consumption, as fodder to animals, and for medicinal and industrial purposes (Kumar *et al.* 2017). Its medicinal value has also been reported in curing ulcers and relief from hemorrhoids (Adams 1975). In 2019, the total okra production was about 54,183 MT from 28,647 acres of land in Bangladesh (BBS 2019). It contributes significantly to filling the gaps when the market suffers from an adequate supply of both winter and summer vegetables.

The organic matter content of Bangladesh soils is poor and generally deficient in nitrogen. Nitrogen is one of the key plant nutrients for plant growth and development. In almost all types of plants, nitrogen is linked to higher chlorophyll biosynthesis, more excellent photosynthetic activity, and efficient solar radiation utilization (Waraich *et al.* 2011). Although phosphorous and potassium deficiencies are not severe, adding these two nutrients is necessary for higher yields. Zinc is another essential micronutrient required for optimum plant growth and it plays a vital role in metabolism. It is required in small but critical concentration for the functioning of several plants' physiological functions like photosynthesis and sugar formation, fertility and seed production, growth regulation, and disease resistance (Solanki *et al.* 2016). Exclusively using inorganic fertilizers may also yield high crop yields quickly; however, it affects soil structure, leading to declining organic matter and environmental pollution (Chen 2008).

Vermicompost technology is a biotechnological process of converting organic waste into compost using specialized earthworms (Fudzagbo and Abdulraheem 2020). Earthworms, in recent times, have become very worthwhile following several kinds of research concerning their ability to efficiently convert organic waste into nutrient-rich compost known as vermicast. Vermicast is proven to escalate crop growth and yield substantially compared to conventional compost and chemical fertilizers because the product is nutrient-rich and contains high-quality humus, plant growth hormones, enzymes, and substances that can protect plants against pests and diseases.

So, the best approaches for soil fertility are, therefore, the integration of both organic and inorganic fertilizers to boost soil fertility and productivity (Bodruzzaman *et al.* 2010) in less expensive ways (Mungai *et al.* 2009) and abate the damage induced by chemical fertilizers (Han *et al.* 2016). Applying organic fertilizers has an emphatic effect on plant growth and production (Lalitha *et al.* 2000). Hence, this research aimed to assess the growth, yield, and mineral nutrient accumulation of okra fruits using vermicompost, nitrogen, and zinc fertilizers applied to the soil. It also intended to evaluate the potential of vermicompost when combined with nitrogen and zinc fertilizers in okra's growth performance and development.

MATERIAL AND METHODS

Description of experimental site and climatic condition

Soil sample was collected from an agricultural field of Araihazar Upazila, Narayanganj (latitude 23° 48' 15'' N and longitude 90° 36' 47'' E). The sampling site was medium highland and is located in AEZ-19 (Old Meghna Estuarine Floodplain). Okra plant growing area was neither so cold nor so hot. The average temperature was 27ºC and the average relative humidity was 78%.

Soil sampling and analysis

Soil samples were collected from the surface of 0-15 cm depth using the composite soil sampling protocol as recommended by the USDA (1951) Soil Survey. Soil analysis was done for organic matter (OM), organic carbon (OC), and available N, P, K, and S. Soil available nitrogen was determined by extracting 10g soil with 1N KCl and distilling by Kjeldahl's distillation apparatus using Devarda's alloy (Huq and Alam 2005). The distillate was then titrated against standard H_2SO_4. Soil samples were extracted by Olsen extractant (0.5M $NaHCO_3$) at pH 8.5 for phosphorous determination (Olsen *et al.* 1954). The exchangeable potassium in soils was extracted with 1N Ammonium acetate at pH 7 and the extracts were analyzed by JENWAY flame photometer (Pratt 1965). Soil available sulfur was determined by turbidity created by suspended barium sulfate using tween-80 stabilizer after extracting with Morgan extractant (0.7N sodium acetate + 0.54N acetic acid) at pH 4.8 (Morgan 1941). The turbidity was measured by a HACH DR 5000 spectrophotometer at 420 nm wavelengths (Page *et al.* 1989). The percentage of organic carbon in the sample was determined by the 'wet oxidation method' as referred to by Walkley and Black (1934). The organic matter was calculated by multiplying the percentage of organic carbon with van-Bemmelen's factor of 1.724 (Piper 1950). pH was determined by using a soil-water medium at a ratio of 1:2.5 using HANNA Instruments HI 2211 pH/ORP meter (Jackson 1973) and EC at a ratio of 1:5 using EUTECH Instruments CON 700) (Richards 1954).

Fig. 1. Okra plants during their growing periods.

Analysis of vermicompost and plant samples

Vermicompost use was analyzed for nutrient composition after being air-dried for 7 days. The dried vermicompost was crushed and passed through a 2-mm sieve. After harvesting, plants were washed with distilled water, air-dried for two days and then oven-dried at 65ºC for three days. Samples were digested with the nitric-perchloric acid mixture (HNO_3: $HClO_4$ = 2:1) for the determination of total P, K, S, Fe, and Zn. Nitrogen was determined by Kjeldahl's digestion method (Jackson 1973). Phosphorous was determined colorimetrically using the vanadomolybdophosphoric yellow color method by using a UV-1800 spectrophotometer at 420 nm wavelength after developing yellow color (Huq and Alam 2005). Potassium was determined using a JENWAY flame photometer (Pratt 1965). Sulphur was measured by a UV-1800 spectrophotometer at 420 nm (Huq and Alam 2005). The contents of iron and zinc were determined by an atomic absorption spectrometer (AAS) (VARIAN AA240) (Jackson 1962).

Experimental design

Treatments including vermicompost, urea (N), and zinc oxide (Zn) were combined and tested as follows: Control (T_1), vc 6 ton ha^{-1} (T_2), N 60 kg ha^{-1} (T_3), Zn 2 kg ha^{-1} (T_4), vermicompost 6 ton ha^{-1} + N 60 kg ha^{-1} (T_5), N 60 kg ha^{-1} + Zn 2 kg ha^{-1} (T_6), vermicompost 6 ton ha^{-1} + Zn 2 kg ha^{-1} (T_7), and vermicompost 6 ton ha^{-1} + N 60 kg ha^{-1} + Zn 2 kg ha^{-1} (T_8). The experiment was conducted in a Completely Randomized Design (CRD) and replicated three times. Vegetative growth, yield, and quality parameters of the fruits of okra were studied.

Sources of materials

Vermicompost was collected from Bhola District and was manufactured by a local NGO. Urea and zinc oxide were collected from Bangladesh Agricultural Development Corporation (BADC) sales Centre, Motijheel, Dhaka.

Pot preparation

Air-dried soil sample of 8 kg was taken in a 10 kg of the plastic pot. Each pot was labeled properly following the treatments. Inorganic fertilizer N as urea and Zn as zinc oxide were applied in quantities of 60 kg ha^{-1} and 2 kg ha^{-1}, respectively, along with vermicompost as an organic fertilizer 6 ton ha^{-1} as per 'Fertilizer Recommendation Guide-2018' for okra plant.

Seed collection, preparation, and sowing

The certified local variety seeds of okra were collected from 'Bangladesh Agricultural Research Institute (BARI)' in Gazipur, which were commonly grown and eaten in Bangladesh. The collected seeds were washed with deionized water and surface sterilized with 0.1% mercuric chloride solution to keep off fungi spores. Before sowing, okra seeds were subjected to a viability test by pouring them inside a pot containing clean water and allowed to stay 5 minutes. The floated seeds were discarded while the sank ones were sown. The seeds were sown two weeks after incorporating vermicompost and inorganic fertilizers. Initially, five seeds per pot were sown, and two weeks after sowing, seedlings were thinned to three per pot for better growth performance.

Weed control and harvesting

Weeding control was manually performed two weeks after germination using a hand hoe. At a week interval, mature okra pods were harvested, then counted and weighed using a weighing balance.

Data collection and statistical analysis

The following parameters were taken during the experiment: plant height, leaf area, number of leaves, number of branches, stem girth, number of fruits, diameter, length, and fresh and dry weight of okra fruits. The collected data were subjected to analysis of variance (ANOVA) using Minitab 20 and MS Excel. The treatment means were compared using the Tukey post-hoc test at $p \leq 0.05$.

RESULTS AND DISCUSSION

Physico-chemical properties of initial soil and vermicompost

The analysis of pre-planting soil and vermicompost is shown in Table 1. The pH of the soil was slightly alkaline, the available nitrogen, phosphorous, and sulphur were relatively low, and the exchangeable potassium was also low. There was a relatively low quantity of sand (11.44%) and clay (22.87%), with a high quantity of silt (65.69%) in the soil, therefore, the textural class was silt loam. The pH of vermicompost was almost neutral, and NPK status was relatively low.

Table 1. Analysis of physico-chemical properties of pre-planting soil and vermicompost.

Soil attributes	Values	Vermicompost attributes	Values
Soil pH	7.39	pH	6.54
EC (µS cm^{-1})	128.80	EC(µS cm^{-1})	358.6
C/N ratio	14.95	C/N ratio	11.02
Organic Matter (%)	0.56	Organic Matter (%)	18.91
Organic Carbon (%)	0.32	Organic Carbon (%)	10.87
Available N (%)	0.002	Total Nitrogen (%)	0.986
Available P (ppm)	4.21	Total Phosphorus (%)	0.765
Exchangeable K (%)	0.06	Total Potassium (%)	0.848
Available S (ppm)	16.08	Total Sulfur(%)	0.186
Total Fe (ppm)	12410	Total Zinc (ppm)	149.4
Total Zn (ppm)	52.36	Total Iron (ppm)	12983

Influence of soil-applied vermicompost, nitrogen, and zinc on okra's vegetative growth

The vegetative variables of okra were affected by different treatments (Table 2). The control (T_1) gave statistically lower values for vegetative variables, where as the pots treated with vermicompost 6 t ha^{-1} + N 60 kg ha^{-1} (T_5) produced higher values for plant height, the number of leaves, leaf area, stem girth, and number of branches. However, the values were not significant with the application of vermicompost 6 t ha^{-1} + N 60 kg ha^{-1} + Zn 2 kg ha^{-1} (T_8). Pots treated with other treatments showed intermediary effects. Similar results were found by Harikrishna *et al.* (2002) in tomato and Prabu *et al.* (2002) in okra. Aboyeji (2018) reported that the combined application of Zn fertilizer with PM and NPK fertilizer resulted in a significant increase in the vegetative parameters of tomatoes. Syed *et al.* (2022) found that vermicompost significantly improved spinach growth parameters and reduced heavy metal concentration in its leaves. Hossain *et al.* (2022) reported that the overall best growth, yield, and nutrient accumulation in the height of chili were achieved in 4 ton ha^{-1} Trichocompost + $N_{23}P_{10}K_{25}$ kg ha^{-1} treatment.

Table 2. Influence of vermicompost, nitrogen, and zinc fertilizer on the vegetative growth parameters of okra at 60 days after sowing (DAS). Means that do not share a letter are significantly different at 5% level by Tukey's Range Test performed separately for different treatments.

Treatments	Plant height (cm)	Number of leaves	Leaf area (cm^2)	Stem girth (cm)	Number of branches
T_1: Control (-VC, -N & -Zn)	42.75^{d}	6^{b}	8.30^{c}	1.60^{d}	5^{b}
T_2: VC 6 t ha^{-1}	46.80^{cd}	8^{ab}	9.25^{bc}	2.25^{c}	6^{ab}
T_3: N 60 kg ha^{-1}	44.50^{bc}	8^{ab}	12.00^{abc}	2.45^{bc}	6^{b}
T_4: Zn 2 kg ha^{-1}	49.25^{d}	7^{ab}	11.00^{abc}	2.40^{bc}	6^{ab}
T_5 VC 6 t ha^{-1} + N 60 kg ha^{-1}	56.00^{a}	11^{a}	14.50^{a}	3.50^{a}	8^{a}
T_6: N 60 kg ha^{-1} + Zn 2 kg ha^{-1}	52.75^{bc}	9^{ab}	12.75^{ab}	2.85^{abc}	7^{ab}
T_7: VC 6 t ha^{-1} + Zn 2 kg ha^{-1}	54.75^{ab}	10^{ab}	11.85^{abc}	2.55^{bc}	6^{ab}
T_8: VC 6 t ha^{-1} + N 60 kg ha^{-1} + Zn 2 kg ha^{-1}	55.80^{a}	11^{a}	13.15^{a}	2.95^{ab}	7^{ab}
Standard deviation	5.24	1.83	2.04	0.56	0.92

Influence of soil-applied vermicompost, nitrogen, and zinc on okra's yield

Data on the yield (number of fruits, diameter, length, and weight of fresh and dry materials) of okra fruits as influenced by soil-applied vermicompost, nitrogen, and zinc are shown in Table 3. There was a significant response of okra yield to different types of treatments. This study illustrated that the number of fruits, their diameter, and length and weight of fresh and dry materials were significantly higher with the pots treated with vermicompost 6 t ha^{-1} + N 60 kg ha^{-1} (T_5). Other treatments gave similar but varying yield values statistically higher than the control (T_1).

Table 3. Influence of vermicompost, nitrogen and zinc fertilizer on the yield of okra fruits at 60 days after sowing (DAS). Means that do not share a letter are significantly different at 5% level by Tukey's Range Test performed separately for different treatments.

Treatments	Number of fruits	Fruits Diameter (cm)	Fruits Length (cm)	Fresh Weight (g)	Dry weight (g)
T_1: Control (-VC, -N & -Zn)	1.50^{c}	4.30^{c}	5.50^{c}	6.15^{e}	0.92^{d}
T_2: VC 6 t ha^{-1}	2.50^{c}	5.00^{bc}	9.75^{b}	7.10^{de}	1.19^{bcd}
T_3: N 60 kg ha^{-1}	2.00^{c}	5.30^{ab}	10.25^{b}	8.75^{cde}	1.76^{ab}
T_4: Zn 2 kg ha^{-1}	3.00^{bc}	5.10^{bc}	10.10^{b}	8.15^{de}	0.99^{cd}
T_5 VC 6 t ha^{-1} + N 60 kg ha^{-1}	6.50^{a}	5.50^{a}	13.50^{a}	13.25^{a}	1.91^{a}
T_6: N 60 kg ha^{-1} + Zn 2 kg ha^{-1}	3.50^{abc}	5.15^{ab}	11.25^{ab}	11.10^{abc}	1.24^{bcd}
T_7: VC 6 t ha^{-1} + Zn 2 kg ha^{-1}	4.00^{abc}	5.25^{ab}	10.80^{ab}	9.35^{bcd}	1.33^{abcd}
T_8: VC 6 t ha^{-1} + N 60 kg ha^{-1} + Zn 2 kg ha^{-1}	6.00^{ab}	5.20^{ab}	11.75^{ab}	11.75^{ab}	1.54^{abc}
Standard deviation	1.81	0.36	2.29	2.42	0.35

Influence of soil-applied vermicompost, nitrogen and zinc on macronutrients, micronutrients and protein content of okra

The concentration of macronutrients (N, P, K, and S), micronutrients (Fe and Zn) and protein content in okra fruits are presented in Table 4. The pots treated with vermicompost 6 t ha^{-1} + N 60 kg ha^{-1} (T_5) significantly increased values for all the macronutrients N, P, K, and S. However, the values were not statistically significant with the pots treated with vermicompost 6 t ha^{-1} + N 60 kg ha^{-1} + Zn 2 kg ha^{-1} (T_8). Compared to the control (T_1), which gave the least value for macronutrients, other pots treated with sole vermicompost or combined with other treatments significantly increased the macronutrient composition of okra. While there was no significant variation in iron (Fe) content in both treatments T_5 and T_8, zinc (Zn) showed significant variations and others showed intermediary effects compared to the control (T_1). Application of all the treatments, either as sole or combined, affected the availability of protein content in okra fruits. Control pots (T_1) gave significantly lower values for protein content compared to the pots treated with vermicompost 6 t ha^{-1} + N 60 kg ha^{-1} (T_5) and vermicompost 6 t ha^{-1} + N 60 kg ha^{-1} + Zn 2 kg ha^{-1} (T_8), where varying but almost similar values were observed with other treatments except for the pot treated with vermicompost 6 t ha^{-1} + Zn 2 kg ha^{-1} (T_7) where the addition of zinc to the vermicompost significantly increased okra fruit's protein content.

Table 4. Influence of vermicompost, nitrogen and zinc fertilizer on the total macro and micronutrient concentrations of okra fruits at 60 days after sowing (DAS). Means that do not share a letter are significantly different at 5% level by Tukey's Range Test performed separately for different treatments.

Treatments	N (%)	P (%)	K (%)	S (%)	Protein (%)	Fe (%)	Zn (%)
T_1: Control (-VC, -N & -Zn)	0.84^{c}	0.13^{c}	0.24^{d}	0.06^{c}	0.13^{c}	0.01^{b}	0.15^{d}
T_2: VC 6 t ha^{-1}	1.38^{abc}	0.18^{a}	0.30^{a}	0.08^{ab}	0.18^{a}	0.01^{ab}	0.17^{cd}
T_3: N 60 kg ha^{-1}	1.37^{bc}	0.19^{bc}	0.28^{bc}	0.07^{bc}	0.19^{bc}	0.01^{ab}	0.23^{abcd}
T_4: Zn 2 kg ha^{-1}	1.42^{abc}	0.18^{abc}	0.27^{c}	0.08^{abc}	0.18^{abc}	0.01^{ab}	0.25^{abc}
T_5 VC 6 t ha^{-1} + N 60 kg ha^{-1}	1.64^{a}	0.28^{a}	0.30^{a}	0.10^{a}	0.27^{a}	0.02^{a}	0.18^{bcd}
T_6: N 60 kg ha^{-1} + Zn 2 kg ha^{-1}	1.50^{ab}	0.17^{ab}	0.29^{ab}	0.08^{abc}	0.17^{ab}	0.01^{ab}	0.27^{ab}
T_7: VC 6 t ha^{-1} + Zn 2 kg ha^{-1}	1.30^{bc}	0.23^{a}	0.28^{bc}	0.07^{bc}	0.23^{a}	0.02^{a}	0.27^{ab}
T_8: VC 6 t ha^{-1} + N 60 kg ha^{-1} + Zn 2 kg ha^{-1}	1.53^{ab}	0.17^{a}	0.30^{ab}	0.09^{ab}	0.27^{a}	0.02^{a}	0.28^{a}
Standard deviation	0.24	0.05	0.02	0.01	0.05	0.005	0.05

Available macronutrient content of post-harvest soil

The concentration of various available macronutrients N, P, K, and S of post-harvest soils are presented in Table 5. There were significant differences ($p \leq 0.05$) compared with the control (T_1) among some treatments, while others showed no significant difference. The maximum amount of available nitrogen (0.008%), phosphorous (9.70 ppm), and potassium (0.08 cmol kg^{-1}) were observed in the treatment containing vermicompost 6 t ha^{-1} + N 60 kg ha^{-1} (T_5), where the sulphur concentration was highest (25.10 ppm) in the pot treated with vermicompost 6 t ha^{-1} + N 60 kg ha^{-1} + Zn 2 kg ha^{-1} (T_8). The lowest amount of macronutrients was observed in the control (T_1) followed by treatments containing sole zinc. The remaining treatments showed intermediary effects.

Analysis of the vermicompost used for the study revealed that it contained a certain amount of macro and micronutrients suitable for cultivating okra. The pre-planting analysis of the potting soil also showed that the nutrient status of the soil was low in major macronutrients. The low fertility status of soil could be due to continuous cropping on the same land from where it was collected over a period of time without amending the soil with organic or inorganic fertilizers. The addition of vermicompost, nitrogen, and zinc indeed increased the amount of macronutrients which were moderately high in amounts in the post-harvest soil compared to the initial soil, even after nutrient uptake by okra plants.

Table 5. Influence of vermicompost, nitrogen and zinc fertilizer on the post-harvest soil of okra fruits at 60 days after sowing (DAS). Means that do not share a letter are significantly different at 5% level by Tukey's Range Test performed separately for different treatments.

Treatments	Available N (%)	Available P (mg kg^{-1})	Exchangeable K (cmol kg^{-1})	Available S (mg kg^{-1})
T_1: Control (-VC, -N & -Zn)	0.002^{d}	2.83^{c}	0.06^{c}	14.84^{c}
T_2: VC 6 t ha^{-1}	0.005^{abc}	4.77^{ab}	0.07^{bc}	17.74^{bc}
T_3: N 60 kg ha^{-1}	0.005^{abcd}	4.32^{abc}	0.07^{bc}	23.89^{ab}
T_4: Zn 2 kg ha^{-1}	0.002^{cd}	3.57^{bc}	0.07^{abc}	15.32^{c}
T_5 VC 6 t ha^{-1} + N 60 kg ha^{-1}	0.008^{a}	9.70^{a}	0.08^{ab}	18.22^{abc}
T_6: N 60 kg ha^{-1} + Zn 2 kg ha^{-1}	0.006^{abc}	3.60^{bc}	0.07^{abc}	15.81^{c}
T_7: VC 6 t ha^{-1} + Zn 2 kg ha^{-1}	0.003^{bcd}	9.20^{a}	0.08^{ab}	24.98^{a}
T_8: VC 6 t ha^{-1} + N 60 kg ha^{-1} + Zn 2 kg ha^{-1}	0.007^{ab}	5.26^{ab}	0.08^{ab}	25.10^{a}
Standard deviation	0.002	2.612	0.007	4.44

The combined application of vermicompost and nitrogen to soil significantly increased soil macro and micronutrient availability compared to the control. This resulted in increased vegetative parameters, which might be considered a positive interaction. Compared to their individual application, higher production of okra was observed when organic and inorganic fertilizers were combined, indicating a synergistic relationship between inputs.

Application of vermicompost 6 t ha^{-1} + N 60 kg ha^{-1} (T_5) significantly improved all the variables tested, though having similar values with vermicompost 6 t ha^{-1} + N 60 kg ha^{-1} + Zn 2 kg ha^{-1} (T_8) in some cases. Hence the optimum dose for better crop quality and productivity might be vermicompost and the dose 6 t ha^{-1} + N 60 kg ha^{-1} (T_5) is recommended for cultivation.

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