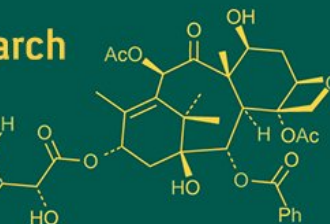
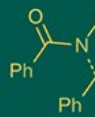


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Mohit Ramteke

M.Sc. Ag. Horticulture
(Vegetable Science) Scholar,
Department of Horticulture,
School of Agriculture Science,
Technology & Research,
Sardar Patel University,
Balaghat, Madhya Pradesh,
India

Mohd Wamiq*

Assistant Professor,
Department of Horticulture,
School of Agriculture Science,
Technology & Research,
Sardar Patel University,
Balaghat, Madhya Pradesh,
India

Avadhesh Singh Choudhary

Head of the Department,
Department of Horticulture,
School of Agriculture Science,
Technology & Research,
Sardar Patel University,
Balaghat, Madhya Pradesh,
India

Pallavi Verma

Assistant Professor,
Department of Horticulture,
School of Agriculture Science,
Technology & Research,
Sardar Patel University,
Balaghat, Madhya Pradesh,
India

Prakash Ghodeswar

Assistant Professor,
Department of Horticulture,
School of Agriculture Science,
Technology & Research,
Sardar Patel University,
Balaghat, Madhya Pradesh,
India

Corresponding Author:**Mohit Ramteke**

M.Sc. Ag. Horticulture
(Vegetable Science) Scholar,
Department of Horticulture,
School of Agriculture Science,
Technology & Research,
Sardar Patel University,
Balaghat, Madhya Pradesh,
India

Influence of organic manure and micronutrient application on growth, yield and quality of okra (*Abelmoschus Esculentus* L.) cv. Arka Anamika under Balaghat region.

Mohit Ramteke, Mohd Wamiq, Avadhesh Singh Choudhary, Pallavi Verma and Prakash Ghodeswar

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Abstract

A field experiment entitled "Influence of Organic Manure and Micronutrient Application on Growth, Yield and Quality of Okra (*Abelmoschus esculentus* L.) Cv. Arka Anamika" was conducted during the Rabi season of 2024-25 at the Horticulture Research Farm, School of Agriculture Science, Technology and Research, Sardar Patel University, Balaghat (Madhya Pradesh). The experiment was laid out in a Randomized Block Design (RBD) with eight treatments and three replications to evaluate the effect of vermicompost and foliar application of micronutrient mixture on growth, yield and quality of okra. The treatments comprised control, vermicompost at two levels (2 and 4 t ha⁻¹), micronutrient mixture at two concentrations (50 and 100 ppm), and their combinations. The results revealed significant variation among treatments for all growth, flowering, yield and quality parameters. The combined application of vermicompost @ 4 t ha⁻¹ + micronutrient mixture @ 100 ppm (T₇) produced the tallest plants (73.95 cm at 60 DAS and 78.66 cm at 90 DAS), maximum number of leaves (45.64 plant⁻¹), highest number of primary branches (4.24 plant⁻¹), earliest first flowering (35.24 days) and 50% flowering (41.37 days). The same treatment also recorded the maximum number of fruits per plant (21.15), fruit length (15.26 cm), fruit diameter (2.17 cm), average fruit weight (19.98 g), fruit yield per plant (422.58 g) and fruit yield (135.22 q ha⁻¹). The study concluded that the integrated application of vermicompost @ 4 t ha⁻¹ along with foliar spray of micronutrient mixture @ 100 ppm is an effective and sustainable nutrient management strategy for enhancing the growth, yield and quality of okra cv. Arka Anamika under the agro-climatic conditions of Madhya Pradesh.

Keywords: Okra, vermicompost, micronutrient, organic manure and yield.

Introduction

Okra (*Abelmoschus esculentus* L. Moench), commonly known as lady's finger or bhindi, is one of the most important warm-season vegetable crops belonging to the family Malvaceae. It is believed to have originated in the Ethiopian region of Northeast Africa, from where it spread to the Middle East, Asia, and Europe and subsequently to the American continent through ancient trade routes. Today, okra is cultivated extensively in tropical, subtropical and warm temperate regions because of its adaptability to a wide range of climatic conditions, short duration, high yield potential and continuous harvesting habit (Kumar *et al.*, 2021; FAOSTAT, 2024). Okra is an often-cross-pollinated crop with a chromosome number of 2n = 130 and is grown throughout the year wherever favorable climatic conditions prevail. The crop performs well under warm and humid weather with an optimum temperature ranging from 25 to 35°C. It can be cultivated successfully on a wide range of soils, although well-drained sandy loam to clay loam soils rich in organic matter are considered ideal for achieving higher productivity (Rashid, 2021). Due to its relatively short crop duration of 50-70 days and prolonged harvesting period, okra has become one of the most profitable vegetable crops for commercial cultivation. India is the largest producer and consumer of okra in the world, contributing more than 60% of the global production. According to the Food and Agriculture Organization (FAOSTAT, 2024), India accounts for approximately 7.0 million tonnes of okra production annually from an area exceeding 0.55 million hectares (Government of India, 2024; Singh *et al.*, 2023). Okra fruits are highly nutritious and are

Valued for their tender edible pods, which constitute an important component of human diets. Fresh fruits contain approximately 88-90% moisture, 2-3% protein, 6-8% carbohydrates, 1-2% dietary fibre, appreciable amounts of calcium, phosphorus, potassium, magnesium and iron and are excellent sources of vitamins A, C and K as well as folates (Gemedet *et al.*, 2020). Moreover, various plant parts are traditionally used in herbal medicine for the treatment of ulcers, inflammation, gastric disorders and diabetes because of their rich phytochemical composition (Petropoulos *et al.*, 2021). Although indiscriminate use of inorganic fertilizers initially increased crop yield, continuous application without adequate organic amendments has resulted in deterioration of soil physical, chemical and biological properties, declining soil organic carbon, nutrient imbalance and reduced fertilizer use efficiency (Lal *et al.*, 2020; Meena *et al.*, 2020). Organic manures also improve soil physical properties by reducing bulk density, increasing aggregate stability, enhancing infiltration rate and improving moisture retention. These changes promote better root proliferation and nutrient absorption, ultimately leading to improved plant growth and higher crop yield (Brady & Weil, 2017; Prasad, 2020). Integrated use of organic manures, biofertilizers and micronutrients has been recognized as an environmentally sound approach capable of improving soil health and nutrient use efficiency (Kumar *et al.*, 2022). Organic manures not only supply essential plant nutrients but also improve soil structure, water-holding capacity, aeration, microbial activity and cation exchange capacity. These improvements ultimately create a favorable rhizosphere environment for better nutrient uptake and plant growth (Brady & Weil, 2017). Application of vermicompost has been reported to enhance seed germination, root proliferation, chlorophyll synthesis, photosynthetic efficiency and biomass accumulation in vegetable crops. Improvement in soil aggregation and microbial activity following vermicompost application further enhances nutrient mineralization and availability of both macro- and micronutrients (Yadav *et al.*, 2022). Balanced nutrition involves not only the application of primary nutrients such as nitrogen, phosphorus and potassium but also adequate supply of essential micronutrients. Micronutrients including zinc (Zn), boron (B), iron (Fe), manganese (Mn), copper (Cu) and molybdenum (Mo) are required in small quantities; however, they play indispensable roles in plant metabolism. These nutrients participate in enzyme activation, chlorophyll formation, protein synthesis, carbohydrate metabolism, nitrogen assimilation, pollen germination and hormone biosynthesis (Alloway, 2022). Deficiency of any one of these nutrients can severely reduce vegetative growth, flowering, fruit development and ultimately crop yield. Micronutrient deficiencies have become increasingly common in intensively cultivated vegetable-growing regions due to continuous cropping, excessive use of high-analysis fertilizers and declining soil organic matter. Zinc deficiency, for instance, restricts auxin synthesis and internodal elongation, while boron deficiency adversely affects cell wall formation, pollen viability and fruit set. Iron deficiency leads to chlorosis and reduced photosynthetic activity, whereas manganese and copper deficiencies impair several enzymatic reactions involved in respiration and carbohydrate metabolism (Marschner, 2019; Alloway, 2022). Foliar application of micronutrient mixtures has therefore become an effective practice for rapidly correcting

nutrient deficiencies and enhancing crop productivity because nutrients supplied through leaves are readily absorbed and utilized by plants.

In view of the above facts, the present investigation entitled "Influence of Organic Manure and Micronutrient Application on Growth, Yield and Quality of Okra (*Abelmoschus esculentus* L.) Cv. Arka Anamika" was undertaken to evaluate the effect of different levels of vermicompost and micronutrient mixtures on growth, yield and quality parameters of okra and to identify an economically viable and environmentally sustainable nutrient management practice for commercial cultivation under the agro-climatic conditions of Madhya Pradesh.

Materials and Methods

Experimental site

The present investigation entitled "Influence of Organic Manure and Micronutrient Application on Growth, Yield and Quality of Okra (*Abelmoschus esculentus* L.) cv. Arka Anamika" was carried out during the Rabi season of 2024-25 at the Horticulture Research Farm, School of Agriculture Science, Technology and Research, Sardar Patel University, Balaghat, Madhya Pradesh, India. The experimental field consisted of well-drained sandy loam soil with medium fertility and slightly alkaline reaction. Prior to sowing, composite soil samples were collected from the experimental field at a depth of 0-30 cm and analysed using standard laboratory procedures. The experiment was laid out in a Randomized Block Design (RBD) comprising eight treatments replicated three times, resulting in 24 experimental plots. The plot size was 2.0 m × 2.0 m with a spacing of 45 cm × 45 cm between plants. The cultivar 'Arka Anamika' was used as the experimental material. Healthy seeds were treated with Captan @ 2 g kg⁻¹ seed before sowing and were sown on 1 October 2024 using a seed rate of 10 kg ha⁻¹. Three seeds were dibbled per hill, and thinning was carried out at 20 days after sowing (DAS) to retain one healthy seedling per hill. Standard cultural practices including irrigation, weeding, hoeing and plant protection measures were followed uniformly in all treatments throughout the crop growth period.

Treatment details

Eight treatment combinations consisting of vermicompost and foliar application of micronutrient mixture were evaluated during the experiment. The treatments included: T₁ - Control; T₂ - Vermicompost @ 2 t ha⁻¹; T₃ - Vermicompost @ 4 t ha⁻¹; T₄ - Micronutrient mixture @ 50 ppm; T₅ - Micronutrient mixture @ 100 ppm; T₆ - Vermicompost @ 2 t ha⁻¹ + Micronutrient mixture @ 50 ppm; T₇ - Vermicompost @ 4 t ha⁻¹ + Micronutrient mixture @ 100 ppm; and T₈ - Vermicompost @ 2 t ha⁻¹ + Micronutrient mixture @ 100 ppm. Vermicompost was incorporated into the soil during final land preparation according to the respective treatments. The micronutrient mixture (Aries Agromin Gold containing ZnSO₄, FeSO₄, CuSO₄ and borax) was dissolved in water and applied as a foliar spray 30 days after sowing according to the treatment schedule. All other agronomic practices were maintained uniformly for every treatment.

Observations recorded

Five healthy plants were selected randomly from the central rows of each experimental plot and tagged for recording

observations, while border plants were excluded to avoid edge effects. Observations on growth, yield and quality parameters were recorded at appropriate crop growth stages using standard procedures. Observations included plant height (cm) at 60 and 90 DAS, number of branches per plant, counted at 60 and 90 DAS; and number of leaves per plant, days to first flowering, days to 50% flowering, days to first fruit harvest, fruit length (cm), fruit diameter (cm), average fruit weight (g), number of fruits per plant, fruit yield per plant (g) and fruit yield per hectare (q ha^{-1}), total soluble solids ($^{\circ}\text{Brix}$) using a hand refractometer and ascorbic acid (vitamin C) content ($\text{mg } 100 \text{ g}^{-1}$ pulp) following standard analytical procedures. These observations were recorded from freshly harvested marketable fruits collected from each treatment.

Statistical analysis

The experimental data obtained for different observations were subjected to analysis of variance (ANOVA) appropriate for a Randomized Block Design (RBD) as described by Gomez and Gomez (1984). The significance of treatment effects was tested using the F-test at the 5% probability level. Wherever the treatment effects were found significant, the Critical Difference (CD) was calculated for comparison of treatment means.

Results and Discussion

The data presented in Table 1 revealed that different combinations of vermicompost and micronutrient application exerted a significant influence on plant height of okra at both 60 and 90 days after sowing (DAS). At 60 DAS, the tallest plants (73.95 cm) were recorded under treatment T_7 (Vermicompost @ 4 t ha^{-1} + Micronutrient mixture @ 100 ppm), which was significantly superior to all other treatments. This was followed by T_8 (70.34 cm), T_6 (70.17 cm), T_5 (69.21 cm), T_4 (68.78 cm), T_3 (67.21 cm) and T_2 (65.97 cm). The shortest plants (63.85 cm) were observed under the control treatment (T_1). A similar trend was observed at 90 DAS, where T_7 recorded the maximum plant height (78.66 cm), whereas the minimum (69.14 cm) was noted under T_1 . The increase in plant height under T_7 over the control was approximately 15.8% at 60 DAS and 13.8% at 90 DAS, indicating the beneficial effect of combined application of vermicompost and micronutrients on vegetative growth. The superior plant height observed under T_7 may be attributed to the synergistic effect of vermicompost and foliar-applied micronutrients, which enhanced nutrient availability and uptake throughout the crop growth period. Vermicompost is a rich source of readily available macro- and micronutrients, humic substances, beneficial microorganisms and naturally occurring plant growth regulators such as auxins, gibberellins and cytokinins. Similar findings have been reported by Acharya *et al.* (2024), Sharma *et al.* (2023) and Singh *et al.* (2023).

The highest number of leaves per plant (45.64) was recorded under T_7 (Vermicompost @ 4 t ha^{-1} + Micronutrient mixture @ 100 ppm), which was significantly superior to all other treatments. Treatments T_8 (43.52) and T_6 (42.68) also produced significantly higher numbers of leaves, followed by T_5 (41.96), T_4 (41.01), T_3 (39.14) and T_2 (37.45). The control treatment (T_1) recorded the lowest number of leaves (36.22). The increase in leaf number under combined application of vermicompost and micronutrients may be

attributed to enhanced nutrient availability, increased cytokinin production and improved photosynthetic efficiency. Similar observations have been reported by Patel *et al.* (2022), Yadav *et al.* (2022) and Acharya *et al.* (2024). Among the different treatments, T_7 (Vermicompost @ 4 t ha^{-1} + Micronutrient mixture @ 100 ppm) recorded the earliest flower initiation (35.24 days), which was significantly superior to all other treatments. This was closely followed by T_8 (36.02 days) and T_6 (36.21 days). Treatments T_5 , T_4 , T_3 and T_2 required 37.36, 38.01, 38.73 and 39.92 days, respectively, for first flower initiation. The control treatment (T_1) recorded the maximum number of days (40.12 days) for initiation of first flowering. Treatment T_7 required the minimum number of days (41.37 days) to attain 50% flowering and was found significantly superior to the remaining treatments. The next best treatments were T_8 (45.93 days) and T_6 (46.17 days). Treatments T_5 , T_4 , T_3 and T_2 recorded 49.27, 50.12, 51.73 and 52.99 days, respectively, whereas the control treatment (T_1) took the maximum period (55.24 days) to reach 50% flowering. Similar findings have been reported by Singh *et al.* (2022), Sharma *et al.* (2023), Acharya *et al.* (2024) and Tasin *et al.* (2024).

Among all the treatments, T_7 (Vermicompost @ 4 t ha^{-1} + Micronutrient mixture @ 100 ppm) recorded the highest number of fruits per plant (21.15), which was significantly superior to all other treatments. Treatment T_8 ranked second with 20.57 fruits per plant, followed by T_6 (19.12), T_5 (18.95), T_4 (18.01), T_3 (17.95) and T_2 (15.24). The lowest number of fruits (14.17 fruits per plant) was obtained under the control treatment (T_1). The increase in fruit number under T_7 may be attributed to improved vegetative growth, early flowering and enhanced reproductive efficiency resulting from balanced nutrient availability. Similar findings have been reported by Singh *et al.* (2022), Sharma *et al.* (2023), Patel *et al.* (2022), Tasin *et al.* (2024) and Acharya *et al.* (2024).

Among the various treatments, T_7 (Vermicompost @ 4 t ha^{-1} + Micronutrient mixture @ 100 ppm) produced the maximum fruit length (15.26 cm) and was significantly superior to all other treatments. The next best treatment was T_8 (14.71 cm) followed by T_6 (14.32 cm), T_5 (13.95 cm), T_4 (13.72 cm), T_3 (13.41 cm) and T_2 (12.86 cm). The minimum fruit length (11.94 cm) was recorded under the control treatment (T_1).

The highest fruit diameter (2.17 cm) was recorded under T_7 , followed by T_8 (2.09 cm), T_6 (2.04 cm), T_5 (1.98 cm), T_4 (1.93 cm), T_3 (1.88 cm) and T_2 (1.82 cm). The control treatment (T_1) recorded the minimum fruit diameter (1.71 cm). The superior fruit diameter under T_7 may be attributed to improved cell enlargement and accumulation of photosynthates within the developing fruits. Vermicompost improves nutrient uptake by enhancing soil microbial activity and root growth, whereas micronutrients regulate enzymatic reactions associated with carbohydrate metabolism and protein synthesis. Zinc enhances auxin production, boron facilitates translocation of sugars, and iron improves chlorophyll synthesis and photosynthetic efficiency. Similar observations have been reported by Singh *et al.* (2023), Acharya *et al.* (2024), and Yadav *et al.* (2022). Treatment T_7 recorded the highest average fruit weight (19.98 g), followed by T_8 (19.21 g), T_6 (18.74 g), T_5 (18.05 g), T_4 (17.56 g), T_3 (17.14 g) and T_2 (16.38 g). The minimum fruit weight (15.24 g) was observed under the

control treatment (T₁). The highest fruit yield per plant (422.58 g) was recorded under T₇ (Vermicompost @ 4 t ha⁻¹ + Micronutrient mixture @ 100 ppm), which was significantly superior to all other treatments. The second highest yield was recorded under T₈ (398.16 g), followed by T₆ (372.44 g), T₅ (349.84 g), T₄ (331.72 g), T₃ (314.65 g) and T₂ (286.53 g). The lowest yield (247.34 g) was obtained in the control treatment (T₁). Treatment T₇ recorded the highest fruit yield per plot, followed by T₈ and T₆, whereas the control treatment (T₁) produced the lowest yield. The increased plot yield under T₇ reflected the cumulative improvement in all yield-contributing traits, including fruit number, fruit size and fruit weight.

The maximum fruit yield (135.22 q ha⁻¹) was recorded under T₇ (Vermicompost @ 4 t ha⁻¹ + Micronutrient mixture @ 100 ppm), followed by T₈, T₆, T₅, T₄, T₃ and T₂, while the

minimum yield was observed in the control treatment (T₁). The increase in fruit yield under T₇ demonstrated the superiority of combined application of vermicompost and micronutrients over their individual application. The highest fruit yield recorded under T₇ may be attributed to the cumulative beneficial effects of improved vegetative growth, early flowering, increased fruit set, larger fruit size and higher fruit weight. Vermicompost improved soil fertility and nutrient availability throughout the crop growth period, while foliar application of micronutrients enhanced physiological efficiency by increasing chlorophyll content, enzyme activity, photosynthesis and reproductive development. Similar results have been reported by Acharya *et al.* (2024), Tasin *et al.* (2024), Sharma *et al.* (2023), Singh *et al.* (2023) and Yadav *et al.* (2022).

Table 1: Influence of Organic Manure and Micronutrient Application on Growth Okra (*Abelmoschus esculentus* L.) cv. Arka Anamika

Treatment	Plant height (cm)		Number of leaves/plants	Number of primary branches / plants	Days to first flower initiation	Number of days taken 50% flowering	Number of fruits / plants
	60 (DAS)	90 (DAS)					
T ₁	63.85	69.14	36.22	3.12	40.12	55.24	14.17
T ₂	65.97	71.15	37.45	3.54	39.92	52.99	15.24
T ₃	67.21	72.34	39.14	3.62	38.73	51.73	17.95
T ₄	68.78	74.15	41.01	3.65	38.01	50.12	18.01
T ₅	69.21	75.12	41.96	3.71	37.36	49.27	18.95
T ₆	70.17	76.02	42.68	3.98	36.21	46.17	19.12
T ₇	73.95	78.66	45.64	4.24	35.24	41.37	21.15
T ₈	70.34	75.98	43.52	4.01	36.02	45.93	20.57
CD at 5%	3.92	4.12	1.01	0.29	0.62	1.24	1.21
SEm±	1.89	1.91	0.47	0.12	0.31	0.61	0.63

Table 2: Influence of Organic Manure and Micronutrient Application on Yield of Okra (*Abelmoschus esculentus* L.) cv. Arka Anamika

Treatment	Length of fruits (cm)	Dimeter of fruits (cm)	Fruits weight (g)	Fruit yield per plant (gm)	Fruit yield per plot (kg)	Fruit yield (q/ha)
T ₁	10.25	1.24	16.01	226.86	3.63	72.60
T ₂	11.12	1.34	17.14	261.21	4.18	83.59
T ₃	12.73	1.37	17.65	316.82	5.07	101.38
T ₄	13.04	1.40	17.98	323.82	5.18	103.62
T ₅	14.15	1.41	18.47	350.01	5.60	112.00
T ₆	14.98	1.47	18.52	354.10	5.67	113.31
T ₇	15.71	1.52	19.98	422.58	6.76	135.22
T ₈	17.31	1.63	19.01	391.04	6.26	125.13
CD at 5%	16.34	1.58	0.18	20.13	0.60	9.20
SEm±	0.61	0.08	0.08	9.39	0.27	5.09

Conclusion

The present investigation entitled "Influence of Organic Manure and Micronutrient Application on Growth, Yield and Quality of Okra (*Abelmoschus esculentus* L.) CV. Arka Anamika" demonstrated that the application of organic manure in combination with micronutrients significantly improved the growth, flowering, yield and quality of okra under the agro-climatic conditions of Balaghat, Madhya Pradesh. Among the eight treatments evaluated, T₇ (Vermicompost @ 4 t ha⁻¹ + Micronutrient mixture @ 100 ppm) proved to be the most effective and consistently recorded superior performance for almost all the growth, yield and quality parameters. This treatment produced the maximum plant height (73.95 cm at 60 DAS and 78.66 cm at 90 DAS), highest number of leaves (45.64 plant⁻¹), maximum primary branches (4.24 plant⁻¹), earliest first

flowering (35.24 days) and 50% flowering (41.37 days), indicating enhanced vegetative growth and earlier reproductive development. It also recorded the highest number of fruits per plant (21.15), maximum fruit length (15.26 cm), fruit diameter (2.17 cm), average fruit weight (19.98 g), fruit yield per plant (422.58 g) and fruit yield (135.22 q ha⁻¹), which were significantly superior to the remaining treatments. The enhanced performance of T₇ may be attributed to the synergistic effect of vermicompost and micronutrient application. Vermicompost improved soil physical, chemical and biological properties, increased microbial activity and ensured a continuous supply of essential nutrients, while foliar application of micronutrients enhanced chlorophyll synthesis, enzyme activation, photosynthetic efficiency, pollen viability and translocation of photosynthates towards developing fruits. These

combined effects resulted in vigorous vegetative growth, early flowering, better fruit development and increased marketable yield. Based on the findings of the present investigation, it can be concluded that the integrated application of vermicompost @ 4 t ha⁻¹ along with foliar spray of micronutrient mixture @ 100 ppm is the most suitable nutrient management practice for improving growth, yield and quality of okra cv. Arka Anamika under the agro-climatic conditions of Madhya Pradesh. Adoption of this nutrient management strategy may help farmers achieve higher productivity while maintaining soil fertility and promoting sustainable vegetable production.

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