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Influence of different organic nutrient sources on total nutrient uptake, nutrient concentration of okra fruit and nutrient use efficiency in okra (*Abelmoschus esculentus* L. Moench)

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Abstract
A field experiment was conducted during *kharif* 2024 at the Organic Farming Research and Training Centre, MPKV, Rahuri to investigate the effect of different organic nutrient sources on total nutrient uptake, nutrient concentration of okra fruit and nutrient use efficiency (NUE) in okra (*Abelmoschus esculentus* L. Moench). The experiment was laid out in a randomized block design with 11 treatments and 3 replications, using farmyard manure (FYM), vermicompost, neem cake, and poultry manure as nutrient sources applied either individually or in combinations to meet 100% N requirement. Results revealed that the treatment T_{10} (50% N through vermicompost along with 50% N through poultry manure) significantly improved total nutrient uptake (N, P and K), indicating their superior mineralization and nutrient release. Nutrient concentration of okra fruit (N%, P%, K% and micronutrients) was found maximum in treatment T_{10} (50% N through vermicompost along with 50% N through poultry manure). Highest Nutrient use efficiency was recorded under treatment T_{10} (50% N through vermicompost along with 50% N through poultry manure), while among sole application of organic manures treatment T_5 (100% N through Poultry manure) recorded the highest AE and AUE, while treatment T_4 (100% N through Neem cake) recorded the highest IUE. Overall, combined application of 50% N through Vermicompost along with 50% N through poultry manure enhanced total nutrient concentration of okra fruit, total nutrient uptake and nutrient use efficiency, highlighting their potential for sustainable okra production in organic farming.

Keywords: Okra, organic manures, fruit quality, nutrient uptake, nitrogen use efficiency, organic farming

Introduction
Okra (*Abelmoschus esculentus* L. Moench) is an important vegetable crop widely grown in tropical and subtropical regions. It is valued for its tender green pods, which are rich in vitamins, minerals, and dietary fiber. With increasing consumer preference for safe and chemical-free vegetables, organic production of okra has gained momentum in recent years.

Fruit quality and nutrient uptake are critical components of crop productivity, particularly under organic systems where nutrient release is dependent on mineralization of organic manures. Previous studies have shown that organic nutrient sources such as farmyard manure, vermicompost, neem cake, and poultry manure not only supply essential nutrients but also improve soil health and microbial activity (Mahmoud *et al.*, 2014; Singh *et al.*, 2020) [4, 7]. However, limited information is available on their combined effect on total nutrient uptake, nutrient concentration of okra fruit, and nutrient use efficiency (NUE) in okra.

Therefore, the present study was undertaken with the objective of evaluating the influence of different organic nutrient sources on on total nutrient uptake, nutrient concentration of okra fruit, and nutrient use efficiency (NUE) in okra under organic farming conditions.

Materials and Methods
The field experiment was conducted during *kharif* 2024 at the Organic Farming Research and Training Centre, MPKV, Rahuri, situated at 19.38°N latitude, 76.65°E longitude, and 657 m

above mean sea level. The soil was classified as Inceptisol with medium fertility status.

Experimental Details

- **Design:** Randomized Block Design
- **Replications:** 3
- **Treatments:** 11
- **Crop:** Okra (Variety: Exp-HY1)
- **Spacing:** 60 × 30 cm
- **Plot size:** Gross: 13.5 × 2.4 m; Net: 12.5 × 1.2 m

Treatment details

T_1: Absolute control
T_2: 100% N through FYM
T_3: 100% N through Vermicompost
T_4: 100% N through Neem Cake
T_5: 100% N through Poultry Manure
T_6: 50% N through FYM + 50% N through Vermicompost
T_7: 50% N through FYM + 50% N through Neem Cake
T_8: 50% N through FYM + 50% N through Poultry Manure
T_9: 50% N through Vermicompost + 50% N through Neem Cake
T_{10}: 50% N through Vermicompost + 50% N through Poultry Manure
T_{11}: 50% N through Neem Cake + 50% N through Poultry Manure

Nutrient Sources

Manures were characterized before application (FYM: 0.51% N; Vermicompost: 1.39% N; Poultry Manure: 2.80% N; Neem Cake: 4.97% N). The required quantities were applied to meet 100% N requirement as per treatment.

Data Collection

Nutrient uptake: N, P, K uptake calculated from plant nutrient concentration × dry matter yield.

Nutrient concentration of Okra fruit: The dried plant sample was analysed for their total N, P, K and micronutrient content.
NUE: Calculated as ratio of fruit yield per unit N applied.

Statistical Analysis

Data were analyzed using ANOVA for RBD as per Panse and Sukhatme (1967) [5]. Treatment means were compared using critical difference (CD) at 5% level of significance.

Results

Nutrient Uptake

The total uptake of nitrogen (N), phosphorus (P), and potassium (K) by okra plants varied significantly across different nutrient management treatments, as shown in Table 1. Nitrogen uptake ranged from 97.72 kg ha^{-1} in the control (T_1) to a maximum of 141.17 kg ha^{-1} in T_{10} (50% N through Vermicompost + 50% N through Poultry manure). Similarly, phosphorus uptake increased from 11.68 kg ha^{-1} (T_1) to 15.16 kg ha^{-1} (T_{10}), and potassium uptake increased from 169.36 kg ha^{-1} (T_1) to 192.61 kg ha^{-1} (T_{10}). The higher nutrient uptake could be due to better nutrient availability and improved root growth in organically enriched soils. Vermicompost in particular enhances microbial activity and releases plant growth-promoting substances, thereby improving nutrient absorption (Kumar *et al.*, 2017) [3]. These results are in align with the findings of Ghosh *et al.* (2018) [2], who reported higher nutrient uptake in okra with integrated organic sources

Table 1: Effect of different organic nutrient sources on total nutrient uptake of okra.

Treatment	Treatment details	Total nutrient uptake (kg ha^{-1})		
		N	P	K
T_1	Absolute control	97.72	11.68	169.36
T_2	100% N through FYM	102.30	13.30	181.21
T_3	100% N through Vermicompost	99.79	13.96	181.03
T_4	100% N through Neem cake	130.90	13.62	182.65
T_5	100% N through Poultry manure	132.73	14.01	183.83
T_6	50% N through FYM + 50% N through Vermicompost	135.12	13.74	183.76
T_7	50% N through FYM + 50% N through Neem cake	136.95	14.08	184.11
T_8	50% N through FYM + 50% N through Poultry manure	139.15	14.75	190.33
T_9	50% N through Vermicompost + 50% N through Neem cake	138.60	14.79	188.59
T_{10}	50% N through Vermicompost + 50% N through Poultry manure	141.17	15.16	192.61
T_{11}	50% N through Neem cake + 50% N through Poultry manure	139.52	14.82	193.29
	SE(m)±	1.37	0.13	0.26
	CD at 5%	4.05	0.39	0.77

Total Nutrient concentration of okra fruit

Significant differences in fruit nutrient concentration of okra were observed among the treatments (Table 2). Among individual application of manures treatment T_5 (100% N through Poultry manure) recorded maximum N, P, K concentration in fruit (2.41, 0.32, 2.14% respectively). While, among treatments with combined application treatment T_{10} (50% N through Vermicompost + 50% N through poultry manure) enhanced N, P, K concentration in okra fruit (2.57, 0.37, 2.42% respectively). This may be attributed to the higher nutrient content and faster mineralization of poultry manure and vermicompost, which ensured adequate nutrient supply during pod development. Similar improvements in fruit quality under organic manures were reported by Mahmoud *et al.* (2014) [4] and Singh *et al.* (2020) [7].

Table 2: Effect of different organic nutrient sources on nutrient concentration of okra fruit.

Treatment	Treatment details	Nutrient concentration of okra fruit (%)		
		N	P	K
T_1	Absolute control	1.68	0.25	1.29
T_2	100% N through FYM	1.86	0.30	1.78
T_3	100% N through Vermicompost	1.80	0.31	1.72
T_4	100% N through Neem cake	2.38	0.31	1.88
T_5	100% N through Poultry manure	2.41	0.32	2.14
T_6	50% N through FYM + 50% N through Vermicompost	2.46	0.33	2.15
T_7	50% N through FYM + 50% N through Neem cake	2.49	0.34	2.18
T_8	50% N through FYM + 50% N through Poultry manure	2.53	0.35	2.34
T_9	50% N through Vermicompost + 50% N through Neem cake	2.52	0.34	2.26
T_{10}	50% N through Vermicompost + 50% N through Poultry manure	2.57	0.37	2.42
T_{11}	50% N through Neem cake + 50% N through Poultry manure	2.54	0.36	2.38
	SE(m) ±	0.027	0.01	0.027
	CD at 5%	0.081	0.03	0.082

Nutrient Use Efficiency (NUE)

NUE values varied significantly among treatments (Table 3). The treatment with combined application of 100% N through Vermicompost along with 50% N through Poultry manure (T_{10}) recorded the highest NUE, followed by the treatment with 50% N through Neem cake along with 50% N through poultry manure (T_{11}). In contrast, FYM alone (T2) exhibited the lowest NUE due to its wider C:N ratio and slower mineralization. Higher NUE under the combined application of vermicompost and poultry manure may be due to synchronized nitrogen release with crop demand. Thakur *et al.* (2019) [8] and Sharma & Banerjee (2021) [6] similarly reported higher NUE under manures with lower C:N ratios.

Table 3: Effect of different organic nutrient sources on nutrient use efficiency (NUE) in okra.

Treatment	Treatment details	Nutrient use efficiency		
		Agronomic efficiency (kg kg^{-1})	Internal use efficiency (kg kg^{-1})	Apparent utilization efficiency (%)
T_1	Absolute control	0.00	28.33	0.00
T_2	100% N through FYM	13.64	31.4	4.58
T_3	100% N through Vermicompost	25.31	36.3	2.08
T_4	100% N through Neem cake	29.01	28.35	33.18
T_5	100% N through Poultry manure	30.49	28.33	35.02
T_6	50% N through FYM + 50% N through Vermicompost	48.57	32.14	37.40
T_7	50% N through FYM + 50% N through Neem cake	52.58	32.62	39.23
T_8	50% N through FYM + 50% N through Poultry manure	72.52	36.73	41.43
T_9	50% N through Vermicompost + 50% N through Neem cake	56.34	33.13	40.88
T_{10}	50% N through Vermicompost + 50% N through Poultry manure	99.45	42.82	43.45
T_{11}	50% N through Neem cake + 50% N through Poultry manure	97.56	41.79	41.80
	SE(m)±	1.14	1.42	1.37
	CD at 5%	3.37	4.19	4.05

Discussion

The results clearly indicate that the combined application of poultry manure and vermicompost enhances total nutrient uptake, nutrient concentration of okra fruit and nutrient use efficiency (NUE) in okra. Their combinations enhanced the performance, likely due to complementary nutrient release patterns. Thus, combined organic nutrient application ensures both productivity and sustainability in okra cultivation.

Conclusion

The study revealed that poultry manure and vermicompost in combination, significantly improved fruit nutrient concentration, nutrient uptake, and nutrient use efficiency in okra under organic farming. Among individual manure treated treatments, 100% N through poultry manure (T_5) was most effective, while among combinations 50% N through Vermicompost along with 50% N through Poultry manure (T_{10}) was found effective. Therefore, combined application of poultry manure and vermicompost is found suitable for achieving higher total nutrient uptake, nutrient concentration of okra fruit and efficient nutrient utilization in organic okra production.

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