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Unravelling the impact of varied organic fertilizer sources on the vegetative and reproductive traits of okra growth and development

Rupesh Kumar MEHTA [1*], Chetana ROY [2], Begam Kumari CHAUDHARY [1], Aniksha MOKTAN [1], Astha KARKI [1], Adhish Kumar ROY [1], Sujata KOIRALA [1], Hikesh GURAGAIN [1], Raju KHATRI [2]

[1] Faculty of Science and Technology, G. P. Koirala College of Agriculture and Research Centre, Purbanchal University, Gothgaun, Morang, Nepal
[2] Faculty of Agriculture, College of Natural Resources Management, Agriculture and Forestry University, Bardibas, Nepal

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* CONTACT

entersgz1907@gmail.com

ABSTRACT

Nepal's pursuit of sustainable food production and rural livelihoods faces challenges amid evolving environmental pressures. Okra (*Abelmoschus esculentus*) cultivation, integral to Nepalese agriculture, demands innovative approaches to enhance productivity while minimizing environmental impact. This study investigates the efficacy of varied organic fertilizers on okra growth and development, aiming to identify sustainable alternatives to chemical fertilizers. The research was conducted at the G.P. Koirala College of Agriculture and Research Centre in Sundarharaicha, Morang, Nepal, from June to August 2023. A Randomized Complete Block Design (RCBD) with eight treatments replicated three times was employed, including recommended NPK dosage and various organic sources. Observations on plant height, primary branches, pods per plant, pod length, diameter, weight per pod, and yield per plant were recorded. Statistical analysis revealed significant variations among treatments. The highest yield was obtained with the recommended NPK dosage (108.84 g/plant), closely followed by biofertilizers like 100% mustard cake (103.70 g/plant) and goat manure (104.28 g/plant). The lowest yield was observed in the control group (76.99 g/plant). Notably, NPK fertilizer consistently outperformed organic alternatives in promoting okra growth and yield. However, among organic fertilizers, mustard cake and goat manure emerged as promising alternatives, showcasing comparable results to synthetic fertilizers. These findings underscore the importance of balanced nutrient management in optimizing okra productivity. Future research should explore integrated nutrient management strategies, combining organic and synthetic inputs, to enhance sustainability and resilience in Nepalese agriculture.

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1. Introduction

Nepal, renowned for its geographical diversity and agricultural heritage, faces a pivotal juncture in its quest for sustainable food production and rural livelihoods (Sharmin et al., 2023; Yadav et al., 2024a). Among the myriad crops cultivated, okra (*Abelmoschus esculentus*), locally known as "bhindi," holds a significant place, both culturally and economically (Mehata et al., 2022a; Mehata et al., 2023b). Okra, belonging to the Malvaceae family, is a warm-season, annual vegetable prized for its tender pods and nutritional value (Yadav et al., 2023; Bhandari et al., 2019). Cultivated worldwide, it thrives in tropical and subtropical climates, making it an ideal crop for Nepal's diverse agroecological zones (Kumar et al., 2017; Singh Bamboriya et al., 2022). As per the Ministry of Agriculture and Livestock Development's report in 2020, the national production of okra amounted to 11.3 tons per hectare, resulting in a total of 122,101.6 metric tons across an area spanning 10,781.4 hectares (Fasakin et al., 2019; Yadav et al., 2023). Its cultivation not only sustains local food security but also serves as a potential source of income for smallholder farmers (Bamboriya et al., 2018; Meiriani et al., 2023). However, sustaining optimal okra yields amidst evolving environmental challenges and agricultural practices remains a critical concern, particularly in the eastern regions of the country (Giri et al., 2020; Al-Joboory et al., 2021).

The cultivation of okra in Nepal traces back centuries, deeply ingrained in traditional farming practices (Abd Alla et al., 2015; Udin et al., 2022). Despite its resilience to various climatic conditions and adaptability to diverse soils, enhancing okra yields remains a persistent challenge (Singh Bamboriya et al., 2022; Mehata et al., 2023c). Although concerted efforts to enhance agricultural productivity through the adoption of modern farming techniques, including the use of chemical fertilizers (Regmi et al., 2022; Kumari Sah et al., 2024), the outcomes have been mixed, with concerns emerging regarding their long-term sustainability and environmental impacts (Yadav et al., 2024b). The widespread use of chemical fertilizers in Nepalese agriculture has led to a myriad of consequences (Sarker et al., 2018), including soil degradation, water pollution, and adverse effects on human health (Nawalkar et al., 2007; Kumar et al., 2017; Mehata et al., 2023a). Moreover, the dependency on these inputs poses economic challenges for resource-constrained farmers (Omotoso et al., 2018), exacerbating inequalities and perpetuating unsustainable agricultural practices (Muhammad et al., 2020; Riasat et al., 2022). Considering these challenges, there is a growing imperative to explore alternative approaches to enhance okra productivity sustainably (Aluko, 2020; Ter and Maga, 2023). Organic farming, grounded in principles of ecological stewardship and natural resource conservation, emerges as a viable solution (Adekiya et al., 2018; Abbas et al., 2019). By eschewing synthetic inputs in favor of organic fertilizers such as compost, manure, and biofertilizers, organic farming not only mitigates environmental harm (Aggrey et al., 2023; Ishwar et al., 2024; Majhi et al., 2024), but also enhances soil fertility and resilience over the long term (Chattoo et al., 2022; Sikdar et al., 2023).

This study aims to identify alternative biofertilizers that could mitigate these issues and offer sustainable solutions. By conducting comprehensive research into the efficacy of various organic fertilizers on okra growth and yield, this study aims to provide valuable insights for both scientific understanding and practical application in agricultural policies and practices. Ultimately, the goal is to promote the adoption of sustainable alternatives to chemical fertilizers among smallholder farmers in Nepal. Through this endeavor, we aspire to pave the way for a more resilient and equitable agricultural future, ensuring the well-being of both people and the environment.

2. Materials and methods

2.1. Experimental site

From June 2023 to August 2023, the field experiment was carried out at the G.P. Koirala College of Agriculture and Research Centre in Sundarharaicha, Morang, Nepal. The climate in Sundarharaicha, Morang, Nepal, is tropical. The region has 20.87 to 34.45 °C average annual temperature which changes along with 135.87 mm of average precipitation. Situated 151 meters above sea level, the location is 26° 40' 49.9" North latitude and 87° 21' 16.8" East longitude. Using a soil test kit box, the experimental site's soil characteristics were assessed qualitatively (Table 1).

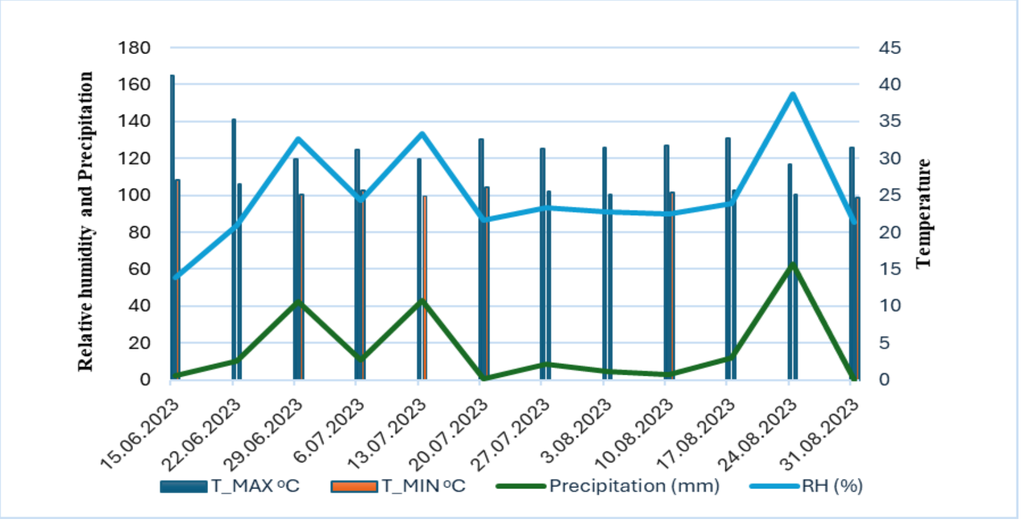

Figure 1. Meteorological data of the research site during study period

Table 1. Characteristics of soil in the research area

Serial Number	Soil characteristics	Properties
1	Organic matter	3.9%
2	pH	6.6
3	Soil texture	Sandy loam
4	Nitrogen	High
5	Phosphorous	Slightly moderate
6	Potassium	moderate

2.2. Experimental design and cultivation practices

The research was conducted following a Randomized Complete Block Design (RCBD), comprising eight distinct treatments replicated three times. In total, 24 plots were established, each occupying an area of 4.5 m² (3m*1.5m), resulting in a combined experimental area of 245 m². A gap of 1.5 m was maintained between two consecutive replications, while a spacing of 0.5 m separated adjacent treatments. Each plot accommodated 25 okra plants, with row-to-row spacing set at 0.6 m and plant-to-plant spacing at 0.3 m. Field preparation commenced seven days prior to sowing, with seeds soaked for 24 hours before planting. Specific treatments were applied to their designated plots, each receiving its calculated dosage. The recommended fertilizer application dosage, provided by the Nepal Agriculture Research Council (NARC), Tarahara, Sunsari, Nepal, stood at 200:180:60 kg NPK/ha, translating to 90:81:27 g NPK per 4.5 m². At sowing, the complete doses of potassium and phosphorus, along with half of the nitrogen dose, were uniformly distributed. The remaining nitrogen dose was split into two applications: one during the flowering stage and the other post-weeding. Irrigation was performed every seven days. The treatment details and their respective doses, symbol are outlined in table 2.

Table 2. Treatment details along with doses

Serial Number	Treatments	Symbol	Doses
1	RD of NPK	T1	200:180:60 kg NPK ha^{-1}
2	Mustard cake 100%	T2	6 tons ha^{-1}
3	Goat manure	T3	10 tons ha^{-1}
4	Mustard cake 75%	T4	4.5 tons ha^{-1}
5	Vermicompost	T5	8.5 tons ha^{-1}
6	Poultry manure	T6	16.67 tons ha^{-1}
7	FYM	T7	15 $tons^{-1}$
8	Control	T8	-

Note: RD: Recommended dose, FYM: Farmyard manure

2.3. Data observations and collection

There were altogether 25 plants in each plot. Out of twenty-five plants, five plants were selected randomly, and the data were collected on the following parameters.

2.3.1. Plant height

The stature of the plants was gauged at intervals of 30, 45, 60, and 75 days after sowing (DAS), employing a measuring tape. The vertical dimension of the plant, from its base to its apex, was assessed weekly until the plant reached a stage of economic yield.

2.3.2. Primary branches

The number of primary branches was enumerated at 30, 45, 60, and 75 DAS, capturing the branching pattern of the plants over time.

2.3.3. Number of pods per plant

The aggregate count of pods per plant (P/P) was assessed for each treatment and replica, commencing from the day of 50% flowering within each plot. Subsequently, counts were made at 30, 45, 60, and 75 DAS to monitor pod development.

2.3.4. Pod length and diameter

Upon reaching 50% maturity, the length and diameter (from midpoint of okra fruit with the help of vernier caliper) of pods were recorded. Pod length was measured manually utilizing a measuring scale, while pod diameter was determined using a vernier caliper. The average dimensions of harvested pods were computed by dividing the total length/diameter by the total number of pods per plant across all treatments and replications.

2.3.5. Pod weight

The weight of harvested pods was quantified using a digital weighing machine. The acquired data were then extrapolated to express yield in tons per hectare, based on the yield per plot.

2.4. Statistical Analysis

Initially, the data was organized in a sequential manner for both replication and treatment blocks using MS Excel 2021 (Microsoft Corporation, Washington, USA). Subsequently, ANOVA analysis was conducted utilizing statistical software (R Studio, Version 4.2.2, Boston, Massachusetts, USA). To evaluate variations in means across various treatments with a significance level of 5%, Duncan's Multiple Range Test (DMRT) was utilized.

3. Result and discussions

3.1. Growth observation parameters

3.1.1. Plant height

The application of various organic fertilizer sources resulted in notable disparities in the plant height of okra, as outlined in Table 3. Initially ranging from 50 to 65 cm, the plant height markedly surged to a maximum of 181 cm. The average height stood at 57.47 cm at 30 days after sowing (DAS), steadily escalating up to 165.82 cm at 60 DAS, before a slight decrease to 169.24 cm. Although statistically non-significant overall, there were variations among treatments at 30, 45, and 60 DAS, with highly significant differences observed at 75 DAS. The highest average plant height was attained with the recommended NPK dosage (132.26 cm), followed by Mustard cake (100%) at 128.40 cm, Poultry manure at 127.60 cm, and Mustard cake (75%) at 127.15 cm. These findings align closely with those of a study by Chattoo et al. (2022), which reported a maximum plant height of 181.01 cm, mirroring our result of 181.44 cm with the recommended NPK dosage. Consistently, studies by Mehata et al. (2022) and Yadav et al. (2023) also observed peak plant heights around 180 cm.

Table 3. Effect of different organic fertilizer combination on plant height

Treatments	Plant Height (PH)				Average PH
	30 DAS	45 DAS	60 DAS	75 DAS	
NPK	61.11[a]	109.07ab	177.39[a]	181.44[a]	132.26[a]
Mustard cake 100%	61.62[a]	109.66[a]	170.00[ab]	172.34[abc]	128.40[ab]
Goat manure	58.15[ab]	106.80[ab]	159.08[b]	166.45[bc]	122.62[bc]
Mustard cake 75%	58.89[ab]	107.11[ab]	166.57[ab]	176.06[ab]	127.15[ab]
Vermicompost	57.49[ab]	107.80[ab]	165.26[ab]	161.62[cd]	123.04[abc]
Poultry manure	57.43[ab]	104.87[ab]	169.00[ab]	179.11[a]	127.60[ab]
FYM	55.48[ab]	101.70[ab]	160.25[b]	164.94[bc]	120.59[bc]
Control	51.47[b]	98.83[b]	158.18[b]	151.98d	115.11[c]
Grand mean	57.75	105.73	165.71	169.24	124.59
SEM	1.05	1.17	1.79	2.21	1.35
CV (%)	9.90	4.98	4.40	3.90	3.93
F-value	NS	NS	NS	**	*

Note: *** Significant at 0.1 % level of significance. ** Significant at 1% level of significance. * Significant at 5 % level of significance. DAS: Day After Sowing. CV: Coefficient of variance. SEM: standard error mean.

NPK fertilizer likely facilitated balanced nutrient provision, fostering vigorous growth. Mustard seed cake might have contributed by gradually releasing nutrients, albeit slightly less effectively than NPK. Similarly, vermicompost, goat manure, and farmyard manure (FYM) yielded comparable plant heights ranging from 120 to 125 cm, as supported by Shampazuraini et al. (2023). This uniformity could be attributed to their rich organic content, enhancing soil fertility and structure, thereby sustaining consistent plant growth. The control group's minimal height (115.11 cm) underscores nutrient deficiency, impeding robust growth. The absence of fertilization restricts essential nutrient availability, resulting in stunted plants, corroborating previous findings by Abbas et al. (2019) and Singh et al. (2023) highlighting nutrients' pivotal role in promoting plant height.

3.1.2. Primary branches

Table 4 delineates the effects of various organic sources on primary branches, showcasing significant variations among treatments. Notably, the primary branches displayed a remarkably high significance level at 0.1%. The progression of the main primary branches, commencing at 3.76 on day 30, exhibited a consistent rise, culminating at a peak of 4.73 by day 75. The most noteworthy observation was the highest number of primary branches recorded with the recommended NPK dose, reaching 5.58, closely followed by 100% mustard cake at 4.63. This outcome echoes the findings of Yadav et al. (2023), indicating the efficacy of NPK in fostering robust branch growth due to its balanced nutrient profile. Interestingly, mustard cake at 75%, alongside goat manure, vermicompost, poultry manure, and farmyard manure, yielded comparable primary branches ranging from 4 to 4.5. This uniformity underscores the ability of these organic sources to provide sufficient nutrients, thereby promoting consistent branch development.

Table 4. Effect of different organic fertilizer combination on primary branches

Treatments	Primary branches (PB)				Average PB
	30 DAS	45 DAS	60 DAS	75 DAS	
NPK	4.04[a]	5.71[a]	6.54[a]	6.03[a]	5.58[a]
Mustard cake 100%	3.76[b]	4.61[b]	5.19[b]	4.95[b]	4.62[ab]
Goat manure	3.82[ab]	4.25[bc]	4.70[bc]	4.59[bc]	4.34[b]
Mustard cake 75%	3.83[ab]	4.25[bc]	4.71[bc]	4.60[bc]	4.34[bc]
Vermicompost	3.80[ab]	4.21[bc]	4.61[bc]	4.51[bc]	4.28[bc]
Poultry manure	3.74[b]	4.12[bc]	4.60[bc]	4.50[bc]	4.24[bc]
FYM	3.73[b]	4.10[bc]	4.62[bc]	4.52[bc]	4.24[bc]
Control	3.38[c]	3.90[c]	4.30[c]	4.21[c]	3.94[c]
Grand mean	3.76	4.39	4.90	4.73	4.44
SEM	0.04	0.12	0.15	0.12	0.10
CV (%)	3.76	6.65	7.46	6.07	5.63
F-value	**	***	***	***	***

This finding resonates with similar observations documented in studies by Al-Joboory et al. (2021) and Abbas et al. (2019), further validating the role of organic fertilizers in enhancing primary branch proliferation. Conversely, the control group exhibited the lowest average number of primary branches at 3.95. This deficiency is attributed to the absence of supplementary nutrients, corroborating findings from Yadav et al. (2023) and Mehata et al. (2022). Such results underscore the vital necessity of supplemental nutrients in stimulating primary branch growth, emphasizing the pivotal role of fertilization strategies in optimizing crop yield and quality.

3.1.3. Pod number per plant

Table 5 outlines the influence of various organic fertilizer sources on the growth and development of pods number per plant, revealing notable disparities among treatments at a significant level of 0.1% throughout the growth period. Initially, pod numbers were modest, averaging just 0.77 per plant across all treatments. However, as the days progressed, the formation of pods number per plant gradually increased, peaking at 4.73 by the 75th day after sowing. The highest pod number count per plant was observed in response to the recommended dose of NPK, reaching an impressive 4.93. This finding resonates with the results reported by Sikdar et al. (2023) and Al-Joboory et al. (2021), emphasizing the pivotal role of NPK in promoting optimal nutrient availability for robust pod development. NPK's balanced combination of essential nutrients, including nitrogen, phosphorus, and potassium, likely played a crucial role in enhancing flower and fruit formation, ultimately leading to higher pod numbers per plant compared to other treatments. Among the various biofertilizers tested, including Mustard cake (100% and 75%), goat manure, poultry manure, and vermicompost, pod numbers ranged between 3.52 and 4.08. These results suggest that these biofertilizers provided a balanced array of essential nutrients, supporting consistent pod development throughout the growth period. However, it's worth noting that their nutrient profiles might not have been as comprehensive as the recommended NPK dosage, resulting in slightly lower pod counts per plant. The findings from Yadav et al. (2023) also corroborate our observations, further strengthening the argument for the efficacy of NPK and the comparable performance of biofertilizers in pod development. Conversely, the lowest pod counts were observed in the farmyard manure (FYM) and control groups, averaging around 3.10 pods per plant. This can be attributed to nutrient deficiencies in these treatments, with FYM likely providing insufficient nutrients and the control group entirely lacking supplemental nutrients. These conclusions find support in the results reported by Mehata et al. (2022) and Bertrand et al. (2024), which also documented minimal pod numbers under the FYM and control treatments. In summary, our study underscores the importance of nutrient management in influencing pod development in okra plants, with NPK emerging as the most effective treatment and biofertilizers providing viable alternatives for sustainable agriculture practices.

Table 5. Effect of different organic fertilizer combination on pod number per plant

Treatments	Pod number per plant (PP)				Average PP
	30 DAS	45 DAS	60 DAS	75 DAS	
NPK	1.07^{a}	4.69^{a}	7.96^{a}	6.03^{a}	4.93^{a}
Mustard cake 100%	0.84^{b}	3.97^{b}	6.57^{b}	4.95^{b}	4.08^{b}
Goat manure	0.75^{bc}	3.73^{bc}	6.34^{b}	4.59^{b}	3.85^{b}
Mustard cake 75%	0.74^{bc}	3.70^{bc}	6.49^{b}	4.60^{b}	3.88^{b}
Vermicompost	0.74^{bc}	3.74^{bc}	6.40^{b}	4.51^{b}	3.84^{b}
Poultry manure	0.73^{bc}	3.61^{bc}	6.23^{b}	4.50^{b}	3.76^{b}
FYM	0.68^{c}	3.50^{c}	5.38^{c}	4.52^{b}	3.52^{c}
Control	0.63^{d}	2.96^{d}	4.60^{c}	4.21^{b}	3.10^{d}
Grand mean	0.77	3.73	6.24	4.73	3.87
SEM	0.02	0.10	0.20	0.15	0.11
CV (%)	9.25	6.08	7.14	7.06	5.52
F-value	***	***	***	***	***

3.1.4. Pod length

Application of various organic fertilizers alongside the recommended NPK dose significantly impacts okra pod length, as evidenced in Table 6. Results were highly significant at the 0.1% level, though initially insignificant during growth. The recommended NPK dose outperforms, yielding a pod length of 13.53 cm, closely followed by goat manure at 13.08 cm.

Table 6. Effect of different organic fertilizer combination on pod length (cm)

Treatments	Pod length (PL)				Average PL
	30 DAS	45 DAS	60 DAS	75 DAS	
NPK	3.54[a]	17.04[a]	17.57[a]	15.98[a]	13.53[a]
Mustard cake 100%	3.47[a]	15.65[ab]	17.03[ab]	15.08[ab]	12.81[ab]
Goat manure	3.52[a]	15.99[ab]	17.34[a]	15.48[ab]	13.08[a]
Mustard cake 75%	3.52[a]	15.63[ab]	17.10[ab]	15.48[ab]	12.93[ab]
Vermicompost	3.48[a]	15.77[ab]	16.95[ab]	15.15[ab]	12.84[ab]
Poultry manure	3.52[a]	15.48[ab]	17.29[ab]	15.54[ab]	12.96[ab]
FYM	3.43[a]	14.28[b]	15.66[b]	14.52[b]	11.97[b]
Control	3.07[b]	11.19[c]	13.32[c]	11.93[c]	9.88[c]
Grand mean	3.44	15.13	16.53	14.89	12.50
SEM	0.04	0.38	0.31	0.26	0.24
CV (%)	5.46	6.62	5.10	3.82	4.78
F-value	NS	***	***	***	***

Previous studies Regmi et al. (2022) and Sikdar et al. (2023) support these findings, attributing NPK's balance and goat manure's organic enrichment to enhanced growth. Similarly, Mehata et al. (2022) found comparable results. Mustard cake (100% and 75%), vermicompost, poultry manure, and FYM yielded slightly lower pod lengths (11-13 cm), likely due to nutrient supply imbalances or slower release rates compared to NPK and goat manure. These results align closely with prior research Mehata et al. (2022) and Yadav et al. (2023). The control group exhibited the lowest pod length (9.88 cm), likely owing to nutrient deficiency and lack of organic supplementation, consistent with earlier findings Bertrand et al. (2024).

3.1.5. Pod diameter

The utilization of various organic fertilizers alongside the recommended chemical fertilizer dosage demonstrates noteworthy impacts on the pod diameter of okra plants, as detailed in Table 7. These findings were highly significant at the 0.1% threshold throughout the growth and development of okra life cycle. Within these treatments, the recommended NPK dose showcased remarkable outcomes, yielding the widest pod diameter at approximately 5.16 cm, closely trailed by goat manure at 5.03 cm. Prior investigations Regmi et al. (2022) and Sikdar et al. (2023) corroborates these results, attributing the optimal nutrient balance from the recommended NPK dosage and the soil enrichment with organic matter from goat manure to the robust development of pods. Similarly, Mehata et al. (2022) observed analogous outcomes in their research. Mustard cake (at 100% and 75% concentrations), vermicompost, poultry manure, and FYM demonstrated comparable results, albeit slightly lower than those of NPK and goat manure, ranging from 4 to 5 cm in diameter. This disparity could stem from the supply of essential nutrients, albeit potentially imbalanced or released at slower rates, consequently resulting in slightly diminished pod diameters compared to NPK and goat manure. These findings closely mirror previous investigations by Mehata et al. (2022) and Yadav et al. (2023). The lowest pod diameter observed in the control group, measuring at 3.76 cm, likely ensued from the dearth of nutrients and inadequate organic matter in the absence of supplementary treatments. This conclusion finds substantial support in the preceding study conducted by Bertrand et al. (2024).

Table 7. Effect of different organic fertilizer combination on pod diameter (cm)

Treatments	Pod diameter (PD)				Average PD
	30 DAS	45 DAS	60 DAS	75 DAS	
NPK	1.63[a]	5.89[a]	6.64[a]	6.49[a]	5.16[a]
Mustard cake 100%	1.59[ab]	5.61[a]	6.23[ab]	6.08[ab]	4.87[a]
Goat manure	1.61[ab]	5.62[a]	6.53[ab]	6.38[ab]	5.03[a]
Mustard cake 75%	1.60[ab]	5.62[a]	6.24[ab]	6.05[ab]	4.87[a]
Vermicompost	1.54[ab]	5.36[ab]	6.07[b]	5.92[b]	4.72[a]
Poultry manure	1.56[ab]	5.50[ab]	6.18[ab]	5.98[ab]	4.80[a]
FYM	1.49[bc]	4.73[b]	5.41[c]	5.27[c]	4.22[b]
Control	1.40[c]	3.90[c]	4.92[c]	4.85[c]	3.76[c]
Grand mean	1.55	5.28	6.03	5.88	4.67
SEM	0.01	0.14	0.12	0.11	0.09
CV (%)	4.05	8.32	4.76	4.53	4.93
F-value	**	**	***	***	***

3.1.6. Fresh weight per pod

The integration of various organic fertilizers alongside the recommended chemical fertilizer dosage significantly influences the fresh weight per pod of okra plants, as indicated in Table 8. These findings were highly significant at the 0.1% threshold throughout the growth and yield period. Initially, the overall mean fresh pod weight among these treatments stood at a modest 25.69 g. However, as days progressed, there was a notable increase in pod weight, reaching a peak of approximately 28.70 g at 60 days after sowing. Among the assortment of fertilizers, synthetic fertilizer NPK emerges as the frontrunner, yielding the highest pod weight, nearly hitting the 29.93 g mark. This outcome aligns robustly with the findings of a previous investigation by Yadav et al. (2023). The superiority of the recommended NPK dosage can be attributed to its meticulously balanced blend of nitrogen, phosphorus, and potassium, which fosters optimal plant growth and development, consequently enhancing pod weight. Similarly, among several organic fertilizers, including mustard cake, goat manure, vermicompost, and poultry manure, slightly lower fresh pod weights are observed compared to NPK. Corresponding results were also documented in the earlier study by Mehata et al. (2022) and Abbas et al. (2019). Conversely, the control group displayed the lowest pod weight, measuring just 22.27 g, consistent with earlier findings from Bertrand et al. (2024). This diminished weight in the control group may be attributed to the absence of supplementary fertilization, resulting in inadequate nutrient uptake and limited support for robust pod development.

Table 8. Effect of different organic fertilizer combination on fresh weight per pod (gram)

Treatments	Fresh weight per pod (WP)				Average WP
	30 DAS	45 DAS	60 DAS	75 DAS	
NPK	28.93^{a}	29.24^{a}	32.04^{a}	29.53^{a}	29.93^{a}
Mustard cake 100%	26.89^{ab}	27.20^{ab}	29.57^{b}	26.90^{ab}	27.64^{b}
Goat manure	26.29^{b}	26.60^{b}	29.16^{bc}	26.19^{abc}	27.06^{b}
Mustard cake 75%	25.82^{b}	26.13^{b}	29.56^{b}	25.93^{abc}	26.86^{b}
Vermicompost	25.77^{b}	26.08^{b}	29.51^{b}	25.87^{abc}	26.80^{b}
Poultry manure	25.50^{b}	25.18^{b}	28.90^{bc}	28.83^{ab}	27.10^{b}
FYM	24.87^{b}	25.18^{b}	27.04^{c}	24.36^{bc}	25.36^{b}
Control	21.49^{c}	21.80^{c}	23.89^{d}	21.92^{c}	22.27^{c}
Grand mean	25.69	25.92	28.70	26.19	26.62
SEM	0.46	0.46	0.50	0.60	0.47
CV (%)	5.05	4.99	4.21	8.73	4.80
F-value	***	***	***	*	***

3.1.7. Yield per plant

The incorporation of various organic fertilizers alongside the recommended chemical fertilizer dose significantly impacts the yield per okra plant, as detailed in Table 9. These results maintained a high level of significance at the 0.1% threshold throughout the growth and yield stages of okra plants. Initially, the average yield per plant across these treatments was modest, measuring at 19.95 g. However, as the cultivation period progressed, there was a noticeable surge in yield, peaking at approximately 130.34 g by the 60th day post-sowing. Within the spectrum of fertilizers tested, synthetic NPK fertilizer emerged as the top performer, yielding the highest output per plant, nearly reaching 108.84 g. This finding strongly corroborates previous research conducted by Yadav et al. (2023). The superiority of the recommended NPK dosage can be ascribed to its meticulously balanced composition of nitrogen, phosphorus, and potassium, which fosters optimal plant growth and development, consequently elevating overall yield. Following this trend, biofertilizers such as 100% mustard cake and goat manure yielded 103.70 g and 104.28 g respectively. Similarly, among the biofertilizers tested, 75% mustard cake, vermicompost, poultry manure, and FYM exhibited comparable results, ranging from 90 to 102 g. Conversely, the control group displayed the lowest yield per plant, measuring just 76.99 g, consistent with earlier findings from Bertrand et al. (2024). This diminished yield in the control group can be attributed to the absence of supplementary fertilization, resulting in inadequate nutrient uptake and limited support for robust overall yield. In conclusion, the study underscores the significant impact of fertilizer type on okra plant yield, with synthetic NPK fertilizer demonstrating the highest efficacy, closely followed by biofertilizers like mustard cake and goat manure. These findings emphasize the importance of balanced nutrient application in maximizing crop productivity.

Table 9. Effect of different organic fertilizer combination on yield per plant (grams)

Treatments	Yield per plant (grams)				Average yield
	30 DAS	45 DAS	60 DAS	75 DAS	
NPK	29.97[a]	131.39[a]	142.34[a]	131.66[a]	108.84[a]
Mustard cake 100%	21.95[b]	128.80[a]	136.56[ab]	127.50[a]	103.70[ab]
Goat manure	19.11[bc]	130.50[a]	138.97[ab]	128.55[a]	104.28[ab]
Mustard cake 75%	18.55[bc]	126.40[a]	134.84[ab]	125.10[a]	101.22[b]
Vermicompost	18.54[bc]	124.41[a]	131.49[b]	122.68[b]	99.35[b]
Poultry manure	18.91[bc]	123.72[a]	131.60[b]	122.96[b]	99.29[b]
FYM	17.49[bc]	112.20[b]	121.44[c]	113.28[b]	91.10[bc]
Control	15.15[c]	90.66[c]	105.48[d]	92.69[c]	76.99[c]
Grand mean	19.95	121.01	130.34	120.55	97.97
SEM	0.97	2.88	2.50	2.60	2.05
CV (%)	12.84	5.04	4.08	4.19	4.29
F-value	***	***	***	***	***

4. Conclusion

Our research underscores the critical role of fertilizer selection in shaping okra yield and growth parameters. While synthetic NPK fertilizer consistently yielded the highest results, our study identified promising organic alternatives, notably 100% mustard cake and goat manure, which demonstrated comparable efficacy. These findings stress the importance of transitioning towards sustainable agricultural practices to mitigate environmental risks associated with chemical inputs. Our study contributes valuable insights to agricultural decision-making, advocating for adopting of organic fertilizers to promote soil health and environmental sustainability. Furthermore, we recommend further exploration of integrated nutrient management strategies and the long-term impacts of biofertilizers on soil health and crop resilience. By advancing our understanding of sustainable agricultural practices, our research ensures food security, supports rural livelihoods, and fosters environmental stewardship in Nepal and beyond.

Compliance with Ethical Standards

Conflict of interest

The author declares no conflict of interest.

Authors' contributions

Rupesh Kumar MEHTA: Conceptualization, funding acquisition, investigation, methodology, resources, software, supervision, writing – review & editing, validation, visualization. **Chetana ROY**: Methodology. **Begam Kumari CHAUDHARY**: Data curation, methodology, writing-original draft. **Aniksha MOKTAN**: Data curation, writing-original draft. **Astha KARKI**: Writing-original draft. **Adhish Kumar ROY**: Data curation, methodology, writing-original draft. **Sujata KOIRALA**: Data curation, writing-original draft. **Hikesh GURAGAIN**: Data curation, methodology. **Raju KHATRI**: Investigation, writing – review & editing, writing – original draft. All authors have read and agreed to the published version of the manuscript.

Ethical approval

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Data availability

Not applicable.

Consent for publication

Not applicable.

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References

Abbas, Z., Mubashir, M., Riaz, U., Javid, Z., Ashraf, M., Rehman, S. ur, Qamar, M. J., Zulqadar, S. A., & Mehdi, S. M. (2019). Combined Impacts of Compost, Poultry Manure and NPK Fertilizers on Yield of Okra Plant (*Abelmoschus esculentus* L.). *Pakistan Journal of Agricultural Research, 32*(3), 456–465. https://doi.org/10.17582/journal.pjar/2019/32.3.456.465

Abd Alla, M., Farrag, D., & Knany, R. (2015). Interaction Effects Between Nitrogen Levels and Biofertilizer Inoculation Methods on Okra Growth, Yield and Pods Quality. *Journal of Plant Production, 6*(12), 2069–2078. https://doi.org/10.21608/jpp.2015.52434

Adekiya, A. O., Aboyeji, C. M., Dunsin, O., Adebiyi, O. V., & Oyinlola, O. T. (2018). Effect of urea fertilizer and maize cob ash on soil chemical properties, growth, yield, and mineral composition of okra, *Abelmoschus esculentus* (L.) moench*. Journal of Horticultural Research, 26*(1), 67–76. https://doi.org/10.2478/johr-2018-0008

Aggrey, H., Osei, M. K., Sarkodie-Addo, J., Kojo, K. Y., Dormatey, R. M., Danquah, E., Asante, M. O. O., Ghanney, P., & Keteku, A. (2023). Response Of Okra (*Abelmoschus esculentus* L.) To The Integrated Application Of NPK, Desert Lion Foliar And Urea Fertilizers*. Agrica, 16*(2), 108–120. https://doi.org/10.37478/agr.v16i2.2666

Al-Joboory, W. M., Abed, Y. M., Salah, A. M., & Hussen, N. S. (2021). Efficiency of some fertilizing combinations on growth and yield in Okra (*Abelmoschus esculentus* L*). Indian Journal of Ecology, 48*(15), 338–340.

Aluko, M. (2020). Prospects of Integrated Application of Moringa (Moringa oleifera) Leaf Extract, NPK Fertilizer & Poultry Manure on Okra (*Abelmoschus esculentus*) Production. *Asian Journal of Research in Crop Science, 5*(1), 1–6. https://doi.org/10.9734/ajrcs/2020/v5i130084

Bamboriya, J. S., Naga, S. R., Yadav, S., Aechra, S., & Yadav, P. K. (2018). Effect of organic manures and biofertilizers on growth, yield attributing characters and yield of okra (*Abelmoschus esculentus* (L.) moench). *Journal of Pharmacognosy and Phytochemistry, 7*(4), 276-278.

Bertrand, G. N., Patrice, N. M., Souleymane, S., Pacôme, K. N., Yves Gilchrist, K. E., Patrick, D. J., Fatim, K. D. S., Daouda, K., & Sorho, F. (2024). Effect of Biofertilizers on the Agromorphological Parameters of Three Okra Cultivars in Southern Côte d ' Ivoire. *Agricultural Sciences, 15*, 408–422. https://doi.org/10.4236/as.2024.154024

Bhandari, S., Pandey, S. R., Giri, K., Wagle, P., Bhattarai, S., & Neupane, R. B. (2019). Effects of different fertilizers on the growth and yield of okra (*Abelmoschus esculentus* L.) in summer season in Chitwan, Nepal. *Archives of Agriculture and Environmental Science, 4*(4), 396–403. https://doi.org/10.26832/24566632.2019.040405

Chattoo, M., Ahmed, N., Wani, M., Mir, S., Khan, S., & Jabeen, N. (2022). Effect of Organic Manures and Inorganic Fertilizers on Growth, Yield and Quality of Bottle Gourd (*Lagenaria siceraria* L.). *Vegetable Science, 38*(2), 135–139. https://doi.org/10.9734/ijpss/2022/v34i2231348

Fasakin, K., Afe, A. I., & Saka, N. A. (2019). Growth and yield response of okra (*Abelmoschus esculentus* L. moench) to fertilizer types and times of application in the southern guinea savanna agro-ecozone of nigeria. *Journal of Agricultural Sciences, 64*(4), 353–366.

Giri, H., Kumar, J., Silas, V. J., Yadav, A., Khadka, H., & KC, A. (2020). Efficacy of biofertilizers and the combinations with chemical fertilizers on vegetative growth and yield of okra [*Abelmoschus esculentus* (L.) Moench]. *The Pharma Innovation Journal, 11*(7), 1221–1226. https://doi.org/10.22271/chemi.2020.v8.i4af.10059

Ishwar, R., Mehata, D. K., Sah, B. K., Chaudhary, A., Subedi, A., Magar, S. P., Khati, J., Yadav, R.R., Neupane, S., & Acharya, R. (2024). Evaluating the response of different synthetic and organic fertilizers on carrot vegetative and reproductive characteristics in Gothgaun, Nepal. *Turkish Journal of Food and Agriculture Sciences, 6*(1), 72-82. https://doi.org/10.53663/turjfas.1427662

Kumar, V., Saikia, J., & Barik, N. (2017). Influence of Organic, Inorganic and Biofertilizers on Growth, Yield, Quality, and Economics of Okra [*Abelmoschus esculentus* (L). Moench] under Assam Condition. *International Journal of Current Microbiology and Applied Sciences, 6*(12), 2565–2569. https://doi.org/10.20546/ijcmas.2017.612.297

Kumari Sah, D., Kumar Mehata, D., Yadav, B., Kumari Majhi, S., Kafle, P., & Oli, B. (2024). Effect of organic and inorganic fertilizers on morphological and yield characteristics of carrot (*Daucus carota*) Cv. New Kuroda in Khotang District, Nepal. *Russian Journal of Agricultural and Socio-Economic Sciences, 3*(147), 76–84.

Majhi, S., Mehata, D., Shah, D., Yadav, N., Chaudhary, P., Shah, S., Timilsina, U., & Rijal, P. (2024). Impact of organic and inorganic fertilizers on the growth and yield of Beetroot (*Beta vulgaris* L.) in the hilly region of Nepal. *International Journal of Agriculture Environment and Food Sciences, 8*(2), 242-250. https://doi.org/10.31015/jaefs.2024.2.1

Mehata, D. K., Kattel, I., Yadav, S. P. S., Bhujel, S., Bhattarai, S., Yadav, P., Sapkota, P., Timsina, S., Lahutiya, V., & Prasad, G. (2022). Varietal trial of okra (*Abelmoschus esculentus* L.) for evaluation of yield and yield parameters. *Journal of Genetics, Genomics and Plant Breeding, 6*(4), 111–116.

Mehata, D. K., Yadav, S. P. S., Ghimire, N. P., Oli, B., Mehta, R. K., & Acharya, R. (2023a). Evaluating the impact of various biofertilizer sources on growth and yield attributes of spring rice (*Oryza sativa* L.) in Eastern Terai of Nepal. *Peruvian Journal of Agronomy, 7*(3), 200-2019. https://doi.org/10.21704/pja.v7i3.1977

Mehata, D. K., Kattel, I., Sapkota, P., Ghimire, N. P., & Mehta, R. K. (2023b). Biofertilizers: A sustainable strategy for organic farming that would ıncrease crop production and soil health. *Plant Physiology and Soil Chemistry, 3*(2), 49–53. https://doi.org/10.26480/ppsc.02.2023.49.53

Mehata, D. K., Neupane, S., Mehta, R. K., Shah, S. K., Chaudhary, M., Rajbanshi, S., Yadav, P. K., & Rajbanshi, R. (2023c). Evaluating the ımpact of various seed priming agents (SPAs) on germination and development parameters of okra (*Abelmoschus esculentus* L. Moench). *AgroEnvironmental Sustainability, 1*(3), 219–228. https://doi.org/10.59983/s2023010303

Meiriani, Lahay, R. R., & Sutra, M. R. (2023). Enhanced production of pruned okra plant (*Abelmoschus esculentus* L. Moench) by applying IAA and Urea fertilizer. *IOP Conference Series: Earth and Environmental Science, 1241*(1). https://doi.org/10.1088/1755-1315/1241/1/012021

Muhammad, M., Kutawa, A. B., & Adamu, M. (2020). Influence of NPK fertilizer and poultry manure on the growth of okra (*Abelmoschus esculentus* L. Moench) in Northern Sudan Savanna Region of Nigeria. *International Journal of Horticulture, Agriculture and Food Science, 4*(6), 196–204. https://doi.org/10.22161/ijhaf.4.6.1

Nawalkar, L. R., Khiratkar, S. D., Badge, S. A., Chopde, N. K., & Dadga, S. S. (2007). Effect of biofertilizers and growth regulator with reduced doses of NPK on growth and yield of okra. *Journal of Soils and Crops, 17*(1), 145–149.

Omotoso, S. O., Fawole, F. O., Aluko, M., & Kehinde-Fadare, A. F. (2018). Growth and yield of two okra (*Abelmoschus esculentus* L . Moench) varieties as affected by organic fertilizer grown on an Oxic Paleustalf in Ekiti State. *Global Advanced Research Journal of Agricultural Science, 7*(4), 137–144.

Regmi, B., Bhattarai, K., Bhusal, N. R., Poudel, S. R., & Kunwar, S. (2022). Effects of various fertilizer combinations on Okra (*Abelmoschus esculentus* L.) varieties for dietary fiber content and vegetative characteristic. *Himalayan Journal of Science and Technology, 6*, 75–86. https://doi.org/10.3126/hijost.v6i1.50658

Riasat, S., Noor, A., Majeed, Y., Amjad, A., Abbasi, K. Y., & Ziaf, K. (2022). Fertilizer source, dose and planting geometry effects on okra seed yield and quality. *Agrobiological Records, 8*, 35–40. https://doi.org/10.47278/journal.abr/2022.007

Sarker, M. M. H., Jahiruddin, M., Moslehuddin, A. Z. M., & Islam, M. R. (2018). Micronutrient responsiveness of cauliflower, okra, and rice in a pattern in piedmont soil. *Journal of Plant Nutrition, 41*(11), 1358–1367. https://doi.org/10.1080/01904167.2018.1452938

Shampazuraini, S., Ameera, Z. M. M. Z., & Noer Hartini, D. (2023). The effect combination of organic and inorganic fertilizer on okra (*Abelmoschus esculentus*) growth. *IOP Conference Series: Earth and Environmental Science, 1182*(1). https://doi.org/10.1088/1755-1315/1182/1/012053

Sharmin, S., Kafi, A. Al, Arfin, M. N. H., & Miah, M. S. (2023). Response of different levels of boron fertilizer on growth and yield of okra (*Abelmoschus esculentus* L.). *IUBAT Review—A Multidisciplinary Academic Journal, 6*(2), 106–114. https://doi.org/10.3329/iubatr.v6i2.71311

Sikdar, A., Zaman, N., Dev, S., Chakma, N., & Sharif, M. O. (2023). Effect of Co-application of different biochars and inorganic fertilizers on the growth and yield of okra (*Abelmoschus esculentus* L.). *Journal of Agroforestry and Environment, 16*(2), 20–27. https://doi.org/10.55706/jae1623

Singh Bamboriya, J., Yadav, P. K., Aechra, S., Yadav, S., Naga, S. R., & Yadav, K. (2022). Effect of organic manures and biofertilizers on chemical and biological properties of soil in okra [*Abelmoschus esculentus* (L.) Moench] on loamy sand soil. ~ 2184 ~ *The Pharma Innovation Journal, 11*(2), 2184–2186. http://www.thepharmajournal.com

Singh, S., Bharose, R., Thomas, T., & Toppo, N. (2023). Impact of integrated nutrient management on growth and yield of okra crop (*Abelmoschus esculentus* L.) var. Deepika. *International Journal of Environment and Climate Change, 13*(9), 112–115. https://doi.org/10.9734/ijecc/2023/v13i92211

Ter, T. S., & Maga, T. J. (2023). Assessment of soil chemical properties and pod yield of okra (*Abelmoschus esculentus*) as influenced by farm yard manure and urea in Southern Guinea Savannah agro-ecology of Nigeria. *Journal of Agricultural Science and Practice, 8*(2), 25–29. https://doi.org/10.31248/jasp2022.389

Udin, J. A., Mony, R., Adrita, P., Sharmin, S., & Husna, M. (2022). Influence of biofertilizer concentration on growth and yield of okra (*Abelmoschus esculentus). International Journal of Business, Social and Scientific Research, 10*(1), 01–05.

Yadav, S. P. S., Bhandari, S., Ghimire, N., Nepal, S., Paudel, P., Bhandari, T., Paudel, P., Shrestha, S., & Yadav, B. (2023). Varietal trials and yield components determining variation among okra varieties (*Abelmoschus esculentus* L.). *Journal of Agriculture and Applied Biology, 4*(1), 28–38. https://doi.org/10.11594/jaab.04.01.04

Yadav, S. P. S., Mehata, D. K., Pokhrel, S., Ghimire, N. P., Gyawali, P., Katel, S., & Timsina, U. (2024). A comprehensive study of banmara (invasive alien plant species): Understanding the invasive potential and ecological consequences for biodiversity conservation, and management strategies. *Journal of Agriculture and Food Research*, *15,* 101031. https://doi.org/10.1016/j.jafr.2024.101031

Yadav, B., Mehata, D. K., Bhandari, S., Shrestha, S., & Sangroula, G. (2024a). Evaluation of different okra (*Abelmoschus esculentus* L.) cultivars for yield and biomass production. *Asian Journal of Research in Agriculture and Forestry, 10*(1), 99-105. https://doi.org/10.9734/ajraf/2024/v10i1273

Yadav, B., Pandit, D. L., Banjade, D., Mehata, D. K., Bhattarai, S., Bhandari, S., Ghimire, N. P., Yadav, P., & Paudel, P. (2024b). Insights into the germplasm conservation and utilization: Implications for sustainable agriculture and future crop improvement. *Archives of Agriculture and Environmental Science, 9*(1), 180–193. https://doi.org/10.26832/24566632.2024.0901026