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ORIGINAL RESEARCH ARTICLE

Comparative analysis of manures and fertilizer on okra growth, yield and its economics in Baitadi, Nepal

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ABSTRACT

Embracing organic techniques can minimize environmental impacts and promote practices that enhance soil and ecological health. A field experiment to study, "Comparative Analysis of Manures and Fertilizer on Okra Growth, Yield and its Economics in Baitadi, Nepal" was conducted at Gokuleshwor Agriculture and Animal Science College in 2023. The experiment was laid out in Randomized Complete Block Design (RCBD) with 3 replications and 7 treatments. The variety used in this experiment was '*Arka Anamika*'. The treatments used in the experiment were FYM, Goat manure, Poultry manure, Vermicompost, Sesame cake, RDF, and Control (no fertilizer). The fertilizer provided the necessary nitrogen, while the insufficient phosphorus and potassium were supplemented with single super phosphate and muriate of potash, respectively. Results revealed that the application of different fertilizers significantly affected various vegetative and reproductive parameters such as germination days, plant height, stem diameter, number of leaves, number of branches, number of buds, number of open flowers, number of pods, pod's length, girth of pods, weight of pods and yield. The results obtained were minimum germination days (4.64) for RDF. Maximum plant height (208.43cm), maximum stem diameter(9.4cm), and number of branches (24.27) were obtained by application of poultry manure at 60 DAS. A maximum number of buds, open flowers, and pods were recorded in poultry manure and RDF application at 75 DAS. The maximum length of the pod (12.52cm) in vermicompost and the maximum girth of the pod (1.59cm) in poultry manure were obtained while the maximum wt. of the pod (14.1gm) in sesame cake. The application of poultry manure obtained a maximum yield per hectare (15.51t/ha). Also in the B: C ratio, Poultry manure exhibited higher (2.65) as compared to other treatments. From this study, we can conclude that poultry manure could contribute to the higher yield and overall attributes of okra.

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INTRODUCTION

Okra commonly known as Lady finger is annual, herbaceous having erect growth habit with bisexual flowers. It belongs to the family Malvaceae which is mostly grown in kharif season throughout the year. The term "Abelmoschus" likely comes from the Arabic phrase "abul-l-mosk," which translates to "father of musk" or "source of musk" referring to the seeds of the plant genus (Patil *et al.*, 2015). They are grown in many parts of the world, especially in tropical and subtropical climates (Prakash *et al.*, 2014; Vinícius-Marin *et al.*, 2017). The term okra was in the use of English by the late 18th century (Arapitsas, 2008; Sindhu & Puri, 2016). Approximately 2,283 known okra species, a significant 1,769 species were found in West Africa, leading to the classification of West Africa as the primary center of okra's origin (Basnet & Khatri, 2023). The cultivated okra containing

chromosome number 2n=130 is an amphidiploid vegetable of *Abelmoschus tuberculatus* (2n=58) and an unknown species with chromosome number 2n=72 (Kumar *et al*., 2017). Approximately 9.953537 million tonnes of okra are produced worldwide (Food, 2020). Okra pods are picked while they are still immature and contain a high amount of mucilage, but before they develop significant fibrousness. It contains carbohydrates, proteins, fat, vitamin A, vitamin C, vitamin B6, folic acid, calcium, magnesium, potassium, iron, Zn, P, β carotene, riboflavin and fiber (VarmuDy, 2011) . It helps to reduce the risk of heart disease, lower blood cholesterol, make the intestinal tract healthy, decrease colorectal cancer and contain both soluble and insoluble fibers (Gemede *et al*., 2015). Antidiabetic and antihyperlipidemic actions have been documented in this plant. So special care should be taken by the patients taking antidiabetic drugs since okra has synergistic effects causing low blood sugar level (Durazzo *et al*., 2018; Roy *et al*., 2014). Okra was grown across 9,337 hectares, yielding 103,353 metric tons, with an average productivity of 11.07 metric tons per hectare (MoALD, 2023). It constitutes 3.32% of Nepal's total vegetable cultivation area (MoALD, 2023). The major producing districts are Bara, Rauthaut, Jhapa, Dhanusha, Kailali, Saptari, Chitwan, Morang and Mohattari whereas Baitadi produces 44,331 metric tons of edible food, but there is a shortage of 8548 metric tons (MOALD, 2018), which is insufficient to meet the rising needs of the local community. According to Cooperation & Division (2022), Okra occupies one of the major areas of Nepal (Area: - 9,584 ha, Production: - 110,565 mt, Yield: - 11.54 mt/ha).

To boost yields and achieve optimal growth, vegetables are often subjected to significant quantities of inorganic fertilizers (Stewart *et al*., 2005). However, the use of inorganic fertilizers alone may cause problems for human health and the environments (Irsan & Riyanto, 2021). The application of chemical fertilizers can also have adverse effects on soil quality. Organic manures are very essential for the proper development of plants as they offer rapid growth with superior quality by containing some nutrients that are necessary for better development. In addition, organic manures help in improving the soil fertility and also the physical properties of soil. Organic manures also have the potential to replace chemical fertilizers to reduce the negative impact of intensive use of chemical fertilizers in agriculture. Mineral fertilizers only assure rapid and short-term growth and yield improvement but become unable to ensure the sustainability of agricultural production (Bhandari *et al*., 2019). Furthermore, the availability of highly concentrated rapidly available nutrient content in inorganic fertilizers which is released for plant uptake instantly, comparatively cost is high and causes nutrient imbalance and soil acidity (Akande *et al*., 2010). The solitary use of chemical fertilizers to meet crop nutrient needs can be detrimental to both soil conditions and environmental health (Chandini *et al*., 2019). Vermicompost supplementation enriches the soil with substances not typically found in chemical fertilizers, and sustainable nutrient supply to crops and maintains soil health (Mal *et al*., 2013). With the objective of finding the best fertilizer for okra growth and production, and to estimate the cost and efficiency of different treatments, an experiment was conducted to investigate the effects of various organic and inorganic fertilizers on okra growth and yield.

MATERIALS AND METHODS

Experiment site

The experiment was carried out on the horticulture farm of Gokuleswor Agriculture and Animal Science College, Gokuleshwor, Baitadi. The latitude and longitude of the research site are 29.6638°N and 80.5420°E respectively. The experiment was conducted from July 3 to October 25, 2023. It is situated at an altitude of 700 meters above sea level (Figure 1).

Climate and Weather

The experiment was conducted in the warm sub-tropical climatic zone with average summer and winter temperatures of 21.1° and 7.7° respectively. The agro-climatic feature of the research field is presented in Figure 2 (Data was made available from the agrometeorological station of Gokuleswor Agriculture and Animal Science College, Baitadi).

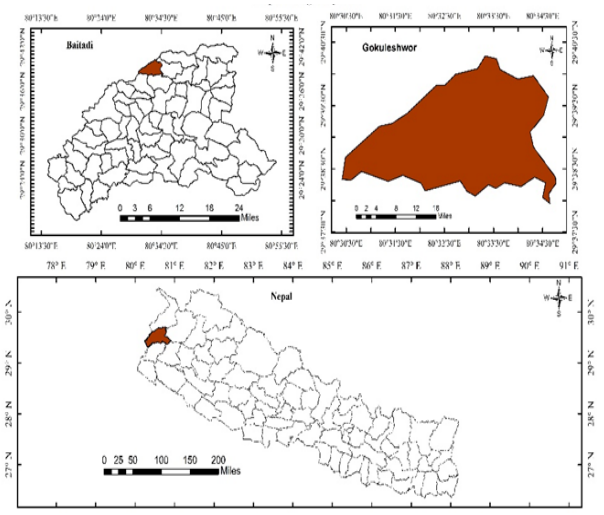

Figure 1. *Map showing the study area.*

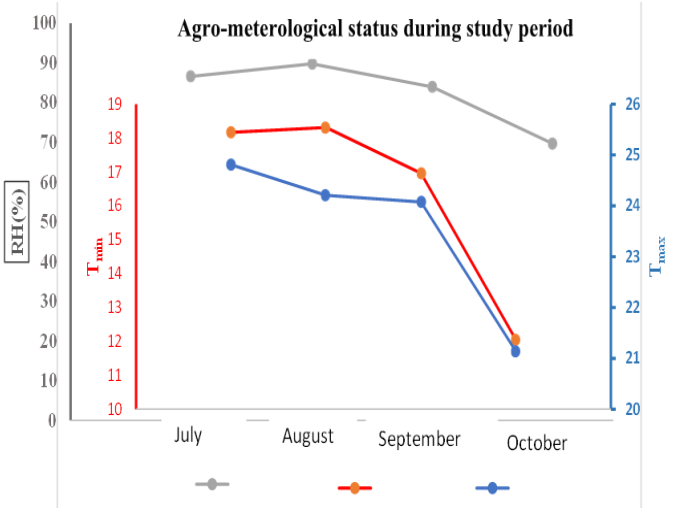

Figure 2. *Agro-Agro-meteorological status during the study period.*

Design of experiment and treatment details

From the 3rd of July to October 25, an extensive field experiment was carried out at Gokuleshwor Agriculture and Animal Science College in Baitadi, Nepal employed with 7 distinctive treatments each replicated 3 times in a randomized complete block design (RCBD). The study adhered to precise plot specifications measuring 2.25m×1.8m while maintaining plot-to-plot separation is 0.5meter and replication to replication distance of 1 meter in each plot, an exacting cultivation of 30 okra plants ensured by thorough and detail-centric nature of investigative endeavor.

Treatment details:
T_1: Farm Yard Manure (FYM)
T_2: Goat Manure
T_3: Poultry Manure
T_4: Vermicompost
T_5: Sesame Cake
T_6: Recommended dose of fertilizer (RDF)
T_7: Control

Cultural operation

The experimental procedure commenced with a comprehensive preparation process, which involved plowing with mini-tiller plows at a depth of about 25cm, subsequent harrowing followed by careful planking. Formulation of plot layout, followed by the application of predetermined treatment quantities based on the previously devised design approximately one week before sowing of okra seeds to dissolve in soil smoothly. The quantities of treatments applied were derived from the computation of Okra's nutrient requirements. According to the Nepal Agricultural Research Council's (NARC), fertilizer recommendation of 200:180:60 kg NPK per hectare (Bhandari *et al.*, 2019). The amount of treatments applied on each plot was computed based on Nitrogen content in different organic manure reports given by the Soil and Fertilizer Testing laboratory, Pokhara given in Table 1. Meanwhile, insufficient phosphorus and potassium were applied from Single Super Phosphate (SSP) and Muriate of Potash (MOP) respectively. A day prior to sowing, the seeds underwent a soaking process in water for 16 hours to enhance germination, followed by an 8-hour drying period on muslin cloth in the shade to promote sprouting. On the day of sowing, each plot underwent hoeing to facilitate aeration, ensuring the thorough incorporation of treatments into the soil after the application of designated chemical fertilizers in their respective assigned plots. Then sprouted seeds were meticulously sowed into each plot of field maintaining a precise spacing of 45cm×30cm recommended practice according to Krishi dairy in 2079, followed by light irrigation. Rigorous manual weeding was performed at two distinct intervals -30DAS and 45DAS to ensure optimal growth of the crop. The uniformity of all other agronomic practices was maintained across all experimental plots, while irrigation was provided in alignment with the checking of soil by ball formation methods. The intricate cultivation journey concluded with harvest of the crop yielding valuable insights and results (Figure 3).

Table 1. Physio-chemical characteristics of experimental soil

Particulars	Properties	Interpretation	
Soil texture	Sandy loam	-	
OM%	1.79	Low	
Soil Ph	5.8	Acidic	
Total N (%)	0.09	Low	
Total P (kg/ha)	23.46	Low	
Total K (kg/ha)	81.6	Low	
Zn (ppm)	0.10095	Very low	
Cu (ppm)	0.6537	Low	
Fe (ppm)	152.8733	Very high	
B (ppm)	1.0546	medium	
Sand (%)	55.8	-	
Silt (%)	29.76	-	
Clay (%)	14.44	-	
Fertilizers	**Total N (%)**	**Total P (%)**	**Total K (%)**
FYM	1.19	1.01	0.90
Goat manure	5.45	1.64	3.13
Poultry manure	3.46	4.37	5
Vermicompost	3.58	1.8	1.85
Sesame cake	4.62	2	1.93

Source: - Soil and Fertilizer Testing Laboratory, Pokhara

Table 2. Amount of different fertilizers added in research field.

Manure	For N(kg)	SSP(g)	MOP(g)
FYM	6.806	25.95	-
Goat manure	1.486	303.285	-
Poultry manure	2.341	114	-
Vermicompost	2.262	201.085	-
Sesame cake	1.753	261.46	-
Synthetic fertilizer (NPK)	114.073 g Urea	158.478 g DAP	40.5 g
Control	-	-	-

Observation recorded

A thorough dataset was compiled, including 10 okra plants from each specific plot excluding plants on the border of each plot. These samples were meticulously gathered at different stages of okra plant's growth i.e., vegetative and reproductive stages. The documented observation covered essential parameters such as seed germination days, plant height (cm), stem diameter (cm), number of leaves, number of branches, number of buds, number of open flowers, number of pods, length of pod (cm), girth of pod (cm), weight of pod (gm), as well as yield (ton/ha).

Data on yield was taken by weighing each harvest from each plot with the help of weighing balance (Model- WT12002NEJ) and expressed it into t/ha by using the following formula:

$$\text{Yield/ha(ton)} = \frac{\text{Yield plot}^{-1} \times 10000}{\text{Area of plot in m}^2 \times 1000}$$

Statistical analysis

Following data collection, the accumulated information was meticulously input into MS-Excel Professional Plus 2019, subsequently undergoing rigorous Analysis of Variance (ANOVA) through the utilization of R (4.3.3). The least significant difference (LSD) test was used to determine the significance of the difference between treatment means at a 5% level of probability. The final result was interpreted with relevant literature by table.

RESULTS AND DISCUSSION

Vegetative parameters

Effect of different fertilizers on seed germination

Seed germination by the effect of different fertilizers is shown in Table 3 in which seed germination rate is earlier in RDF i.e., 4.64 days which is followed by poultry manure i.e., 5.13 days whereas the maximum days needed for germination in control i.e., 5.34 days which is at par with all organic manures. Omidire *et al.* (2015) explained that the nutrients in mineral fertilizers are relatively high, and the release of these nutrients is quick because there is no need for decomposition. Poultry manure is one of the excellent organic sources that can supply macro and micronutrients during mineralization which leads to increased organic matter content, enhanced soil texture, structure, aeration, moisture holding capacity, and infiltration capacity of the soil (Adekiya *et al.*, 2020a). Poultry manure was identified as a better source of organic manure for okra production than cow dung and compost (OfosuAnim *et al.*, 2006).

Effect of different fertilizers on plant height of okra

It is shown in Table 3 that plant height is maximum in poultry manure whereas control showed minimum plant height out of all other fertilizers. This result corroborated the findings of (OI *et al.*, 2003) in okra production in which they reported that organic manures especially poultry manure could increase plant height of crops when compared with other source of manure. This agrees with the study of Khalid *et al.* (2014) who reported that Poultry manure contains essential nutrients which are associated with high photosynthetic activities that promote root and vegetable growth. Otomoso and Johnson (2015) revealed that poultry manure gave the highest plant height and the greatest number of pods. The highest plant height was found in poultry manure which was significantly at par with the chemical and goat manure (Poudel, 2018). Technology *et al.*, (2020) mentioned that poultry manure application produces the tallest plant. Okee *et al.* (2021) also reported that there was a significant increase in okra on the plot treated with 10t/ha of poultry manure.

Effect of different fertilizers on stem diameter of okra

From Table 3, we can conclude that poultry manure showed the best result whereas minimum stem diameter was found in the control. This result is supported by Fagwalawa & Yahaya (2016) recorded that poultry manure exhibited the highest stem diameter out of other treatments. Acharya & Thapa (2023) also recorded that the highest stem diameter i.e., 3.467 cm by Poultry manure.

Effect of different fertilizers on the number of leaves of okra

Table 3 showed that impacts of different fertilizers on the Number of leaves of okra become non-significant. This may be due to the falling of lower leaves due to wilting. MOAD reported the highest leaf area in response to poultry manure (MOALD, 2018). Jamkatel *et al.* (2020) also reported that the okra leaf in response to different fertilizers varied significantly at 30, 40, and 50 DAS, and increased with time in all the responses but was non-significant at 60 DAS.

Table 3. Effect of different fertilizers on the vegetative parameters of okra.

Treatment	Seed germination (days)	Plant height (cm) 60DAS	Stem diameter (cm) 60DAS	Number of leaves 60DAS	Number of branches 60DAS
FYM	5.33^{a}	150.83^{b}	6.7^{b}	30.11	17.72^{c}
Goat manure	5.23^{a}	151.87^{b}	7.3^{b}	30.74	18.78^{bc}
Poultry manure	5.13^{a}	208.43^{a}	9.4^{a}	38.3	24.27^{a}
vermicompost	5.2^{a}	142.33^{b}	6.51^{b}	28.4	17.8^{c}
Sesame cake	5.32^{a}	160.4^{b}	7.7^{b}	32.88	19.29^{bc}
RDF	4.64^{b}	162.92^{b}	7.83^{b}	43.11	22.69^{ab}
Control	5.34^{a}	144.87^{b}	6.66^{b}	29.77	17.07^{c}
LSD	0.43	39.71	1.47	11.049	4
SEM	0.05	4.87	0.18	1.36	0.49
F-probability	*	*	*	NS	*
CV%	4.67	13.93	11.13	18.64	11.44
Grand mean	5.17	160.24	7.44	33.33	19.66

Means with the same letter significant at p=0.05. NS represents non-significant difference among each other at 5% level of significance. *, **, *** represents significant difference in <0.5, <0.1 and <0.001 respectively, LSD= Least Significant difference, SEM= Standard error of mean CV= Coefficient of variation.

Table 4. Effect of different fertilizers on the reproductive parameters of okra.

Treatment	Number of buds 75DAS	Number of open flowers 75DAS	Number of pods 75DAS	Pod length (cm)	Girth of Pod (cm)	Wt. of Pod (gm)	Yield (ton/ha)
FYM	10.47^{cd}	0.76^{abc}	2.16^{bc}	11.16^{bc}	1.41^{b}	12.5^{ab}	8.36^{e}
Goat manure	12.3^{bcd}	0.98^{abc}	2.89^{b}	11.32^{bc}	1.44^{b}	12.22^{ab}	8.67^{e}
Poultry manure	17.53^{a}	1.33^{a}	4^{a}	11.96^{ab}	1.59^{a}	14.04^{a}	15.51^{a}
vermicompost	12.8^{bc}	0.57^{bc}	2.87^{b}	12.52^{a}	1.43^{b}	13.32^{a}	12.26^{d}
Sesame cake	14.8^{ab}	1.13^{ab}	2.87^{b}	12.15^{ab}	1.46^{b}	14.1^{a}	14.39^{b}
RDF	18.22^{a}	1.27^{a}	4.43^{a}	11.71^{abc}	1.52^{ab}	13.98^{a}	13.07^{c}
Control	8.53^{d}	0.43^{c}	1.63^{c}	10.73^{c}	1.23^{c}	10.76^{b}	6.6^{f}
LSD	3.91	0.55	1.09	1.04	0.12	1.74	0.61
SEM	0.48	0.07	0.13	0.13	0.01	0.21	0.07
F-probability	**	*	**	*	***	**	***
CV%	16.26	33.66	20.74	5.02	4.57	7.55	3.05
Grand mean	13.52	0.93	2.98	11.65	1.44	12.99	11.26

Means with the same letter significant at p=0.05. NS represents non-significant difference among each other at 5% level of significance. *, **, *** represents significant difference in <0.5, <0.1 and <0.001 respectively, LSD= Least Significant difference, SEM= Standard error of mean CV= Coefficient of variation.

Figure 3. *Okra cultivation in Gokuleshwor, Baitadi, Nepal.*

Effect of different fertilizers on the number of branches of okra

The effect of different fertilizers on the Number of branches of okra is shown in Table 3 there were significant differences from a statistical viewpoint. Poultry manure plot had the highest number of branches with a mean of 24.27 which was followed by 22.69 from RDF while the control had the lowest number of branches with a mean of 17.07. This may be due to the presence of easily absorbable poultry manure significantly promoting plant root uptake, resulting in a notable boost in morphological plant growth. Khandaker *et al.* (2017) showed that the number of branches was significantly (P ≤ 0.05) affected by different types of organic manure and NPK fertilizer used. The NPK fertilizer plot had the highest number of branches followed by poultry manure while no fertilizer had the lowest number of branches. Onwu *et al.* (2014) also reported that the application of poultry manure recorded the highest number of branches and was significantly different from all other treatments. The highest number of branches was found in poultry manure and the lowest is exhibited by control (Technology *et al.*, 2020).

Reproductive parameters

Effect of different fertilizers on the number of buds of okra

It can be concluded from Table 4 that at 75DAS, both poultry manure and RDF show the best result at the number of buds i.e., 17.53 and 18.22 respectively followed by sesame cake with a mean of 14.8 which are statistically at par with both poultry manure, and RDF whereas the lowest mean 8.53 was recorded on control. A similar result was reported from Bhandari *et al.*, (2019) who recorded that at first poultry manure and RDF became higher in comparison to sesame cake at 60DAS and gradually at 75DAS, they became at par with sesame cake.

Effect of different fertilizers on the number of open flowers

From Table 4, we can conclude that at 75 DAS, the highest number of open flowers was in poultry manure and RDF with mean of 1.33 and 1.27 respectively which was significantly at par statistically whereas the lowest number of open flowers was in control with a mean of 0.43. This result was supported by Khandaker *et al.* (2017) that the number of flower per plant were significantly ($P \leq 0.05$) increased by the application of different types of organic fertilizer. More flowers were recorded in RDF plots followed by poultry manure and the lowest in no fertilizer plots. Nweke *et al.* (2013) reported that more flowers were recorded in poultry manure compared to the other treatments.

Effect of different fertilizers on the number of pods

Table 4 represented that at 75DAS, the highest number of pod is in poultry manure and RDF with mean 4 and 4.43 which were statistically at par whereas the lowest number of pod was in control with mean 1.63. This may be due to the 48% of N in incorporated poultry manures can be mineralized within 10 weeks which was reported by Ghodia (2012). Khandaker *et al.* (2017) revealed that the NPK fertilizer plot had the highest number of pods followed by poultry manure while no fertilizer had the lowest number of pods. Baghlani *et al.* (2024) also recorded that the highest number of pods were recorded in Poultry manure treatment in mungbean. The result was supported by Onwu *et al.* (2014) who reported that the application of poultry manure gave the most in pod yields while the least was from the control plot.

Effect of different fertilizers on the pod Length

It can be concluded from Table 4 that the highest pod length was also in vermicompost with a mean of 12.52 which was followed by sesame cake and poultry manure with a mean of 12.15 and 11.96 respectively whereas the lowest pod length was in control with a mean of 10.73. This can be due to the ability of vermicompost to maintain nutrient availability throughout the growing season (Akhter, 2020; Bano *et al.*, 2018). This result was also supported by Shahriazzaman *et al.* (2014) indicted that the application of poultry manure produced the longest pod length which was statistically not significant with vermicompost and the lowest pod length was recorded in control. OfosuAnim *et al.* (2006) also mentioned that Poultry manure produced the longest pod.

Effect of different fertilizers on the girth of Pod of okra

We can conclude from Table 4 that the impact of different fertilizers significantly impacts on girth of pods of okra. The highest girth of pods was recorded on poultry manure with mean 1.59 followed by RDF of 1.52 mean while the lowest was occupied by control with mean 1.23. The research outcomes align with the study conducted by Adhikari & Piya (2020) reported that PM contributes to the highest pod's girth compared to other treatments. This result is also supported by OfosuAnim *et al.* (2006) that a Significant ($P < 0.05$) increase in pod diameter was observed in poultry manure-treated plot as compared to control.

Table 5. Benefit-Cost (BC) ratio of cultivation of Okra (ton/ha).

Input required per ha	Particulars	Amount (NRs/ha)	Require amount/ ha	NRs	Respective treatments (NRs/ha)	Total costs (NRs/ha)	Gross returns (NRs/ha)	Net returns (NRs/ha)	BC ratio
FYM	Rental value of land	45,000/-	16.804ton	Rs1,000/ton	16,804/-	1,71,304/-	4,18,000/-	2,46,696/-	1.44
Goat manure	Field preparation	25,050/-	3.669ton	Rs3,300/ton	12,107.7/-	1,66,607.7/-	4,33,500/-	2,66,892.3/-	1.60
Poultry manure	Seed cost	10,000/-	5.780ton	RS10,000/ton	57,800/-	2,12,300/-	7,75,500/-	5,63,200/-	2.65
Vermicompost	Sowing cost	12,000/-	5.585ton	Rs20,000/ton	1,11,700/-	2,66,200/-	6,13,000/-	3,46,800/-	1.30
Sesame cake	Intercultural operation	22,000/-	4.328ton	Rs20,000/ton	86,560/-	2,41,060/-	7,19,500/-	4,78,440/-	1.98
RDF	Harvesting	22,000/-	Urea=298.68kg-DAP=391.3Kg and MOP=100 Kg	Urea=Rs80/kg, DAP=Rs100/kg and MOP=Rs80/kg	Urea=Rs23,894.260/- DAP=Rs39,130/- and MOP=Rs8,000/-	2,25,524.26/-	6,53,500/-	4,27,975.74/-	1.89
Control	Contingency cost	15,450/-	-	-	-	1,54,500/-	3,30,000/-	1,75,500/-	1.13
Total		1,54,500/-							

Sold at NRs: Rs50/kg of okra

Effect of different fertilizers on wt. of pod of okra

From Table 4, we can conclude that different fertilizers exhibit significant impacts on the wt. of pods of okra. Poultry manure, sesame cake, RDF, and vermicompost with means 14.04, 14.1, 13.98, and 13.32 respectively occupied the highest wt. of individual pods whereas control with 10.76 mean exhibits the lowest wt. of individual pods. This result may be due to the application of poultry manure contributes to the soil's improved nutrient status and water retention by facilitating the easy solubilization of released plant nutrients. The result was supported by OfosuAnim *et al.* (2006) that pod's fresh weight per plant was significantly ($P < 0.05$) increased with poultry manure application compared to the control. Applying poultry manure contributes to the soil's improved nutrient status and water retention by facilitating the easy solubilization of released plant nutrients (Rasool *et al.*, 2023).

Effect of different fertilizers on yield of okra at ton/ha

The effect of different fertilizers on the yield of okra at ton/ha is shown in Table 4 we can summarize that the impact of fertilizers on yield is highly significant. Poultry manure resulted in the highest productivity of okra i.e., 15.51t/ha which is followed by sesame cake and RDF of 14.39t/ha and 13.07t/ha respectively whereas control group exhibited the lowest yield i.e., 6.6t/ha. This may be due to the application of inorganic fertilizer led to improvements exclusively in soil chemical parameters, while soil physical properties such as bulk density and water holding capacity remained unaffected. Similarly, manures such as poultry manures and sesame cake exhibit water infiltration rate, water holding capacity, and the hydraulic conductivity of soil. Application of organic manures may also increase soil pH as the soil of the farm is acidic. Similarly, the use of Poultry manures may also help to correct Zn and Ca deficiencies in the soil as the soil of the field was deficient in Zn which also corroborates with (Dróżdż *et al.*, 2020; Wieremiej, 2017). This result is supported by Adekiya *et al.* (2020b) indicated that poultry manure increased okra yield in both 2 years of the experiment. Jamkatel *et al.* (2020) reported that in response to different doses of fertilizers, the maximum yield was obtained in poultry manure whereas the lowest was in control conditions. The increase in fresh pod weight leads to a higher yield of okra due to the application of poultry manure causing easy solubilization of plant nutrients leading to enhanced water-holding capacity and nutrient status of the soil (Najah *et al.*, 2021). It was also reported that poultry manure seems to promote higher growth and yield of okra (Tiamiyu *et al.*, 2012).

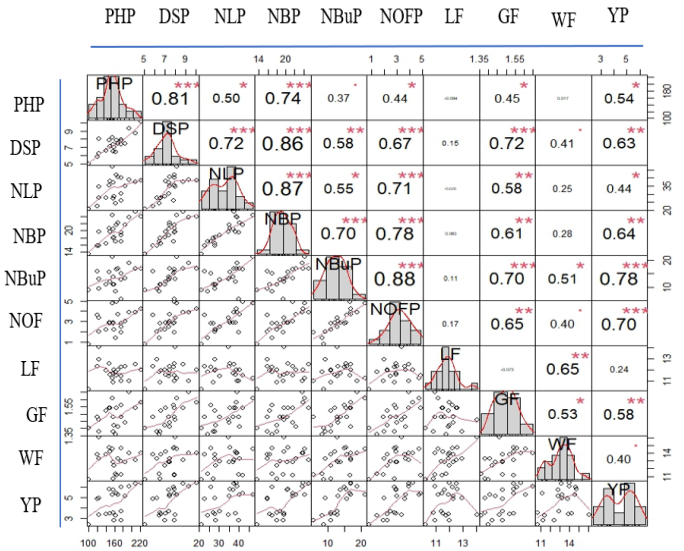

Figure 4. *Correlations and distribution of the growth (PHP: Plant height Plant^{-1}, DSP: Diameter of Stem Plant^{-1} NLP: Number of Leaves Plant^{-1}, NBP: Number of Branch Plant^{-1}), Yield components (NBuP: Number of Buds Plant^{-1}, NOFP: Number of Open Flowers Plant^{-1}, LF: Length of Fruit, GF: Girth of Fruit, WF: Weight of Fruit) and YP: Yield/Plot of Okra); *, ** and *** Significant at p<0.05, p<0.01 and p<0.001 respectively*

Correlation among the growth and yield components

The correlation between growth, yield, and yield components of okra in this research is given in Figure 4. It is seen from the figure that there are positive and negative correlations between growth, yield, and yield components. There are strong positive correlation among the PHP and DSP (r= 0.81***), PHP and NBP (r= 0.74***), DSP and NLP(r=0.72***), DSP and NBP(r= 0.86***), DSP and GF(r= 0.72***), NLP and NBP (r= 0.87***), NLP and NOFP(r=0.71***), NBP and NBuP(r=0.70***), NBP and NOFP (r=0.78***), NBuP and NOFP(r=0.88***), NBuP and GF (r=0.70***), NBuP and YP(r=0.78***), NOFP and YP(r=0.70***). Similarly, there are moderate correlationship between PHP and NLP (0.50*), PHP and NOFP(r=0.44*) PHP and GF(r= 0.45*), PHP and YP(r=0.54*), DSP and NBuP(r=0.58**), DSP and NOFP (r=0.67***) DSP and WF(r=0.41*), DSP and YP(r=0.63**), NLP and NBuP(0.55*), NLP and GF(r=0.58**), NLP and YP(r=0.44*), NBP and GF(r=0.61**), NBP and YP(0.64**), NBuP and WF (r=0.51*), NOFP and GF(r=0.65**), NOFP and WF(r=0.40*), LF and WF(r=0.65**), GF and WF(r=0.53*), GF and YP(r=0.58**), WF and YP(r=0.40*). Likewise, there is weak positive correlation among the PHP and WF(r=0.017), DSP and LF(r=0.15), NLP and WF(r=0.25), NBP and LF(r=0.063), NBP and WF(r=0.28), NBuP and LF(r=0.11), NOFP and LF(r=0.17) LF and YP(r=0.24) whereas strong negative correlation is between PHP and LF(r=-0.084), NLP and LF(r=-0.026), LF and GF (-0.073).

Economics of production

From the B: C ratio, we can conclude that poultry manure was recorded best out of all other treatments with b: c ratio of 2.65 which was followed by Sesame cake (1.98) where the lowest was recorded on the control with 1.13 followed by vermicompost (1.30). Due to high cost of manure, the BC ratio seems to be quite low in vermicompost though it produced comparatively superior yield than FYM and Goat manure. T3 (Poultry manure) exhibits the highest BC ratio indicating that it is economically viable and efficient.

Conclusion

From this study, it was concluded that poultry manure exhibited the best impacts in most of the yield-attributing parameters of okra such as plant height/plant, stem diameter/plant, number of branches/plant, number of buds/plant, number of open flowers/plant, number of pods/plant, girth of the pod, the weight of pod, yield along with the highest b:c ratio i.e., 2.65. Poultry manure was superior amongst all vegetative and reproductive parameters of the plant. Hence, the use of poultry manure becomes beneficial in terms of economic and ecological points of view. Furthermore, multi-trial and multi-location research could be conducted to suggest the optimum dose of poultry manure to achieve higher yield and subsequently greater profits.

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DECLARATIONS

Authors contribution

Conceptualization, methodology, resources, software, validation, investigation, data curation, formal analysis, writing-original draft preparation: S.P.A.; Data curation, supervision, visualization, validation, writing-review, and editing: C.G. All authors have read and agreed to the published version of the manuscript.

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Consent for publication: Both authors gave their consent to publish.

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