RESEARCH ARTICLE

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Impact of organic and inorganic fertilizers on the growth and yield of Beetroot (*Beta vulgaris* L.) in the hilly region of Nepal

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Abstract
The use of both organic and inorganic fertilizers plays a crucial role in farming practices in Nepal, depending on their availability. Applying fertilizers like compost, vermicompost, goat manure, and NPK has shown significant effects on various aspects of plant growth and yield. This study was conducted in Diktel, Khotang district of Nepal, from March 14th to June 7th, 2023, aiming to evaluate how different organic and inorganic sources affect the growth and yield of beetroot (Beta vulgaris L.). The experiment followed a one-factor randomized complete block design (RCBD) with four replications, involving five treatments: T1: 100% Compost manure, T2: 100% Vermicompost, T3: 100% Goat manure, T4: 100% NPK, and T5: Control. The results clearly showed that both vegetative and reproductive traits were significantly varies among several treatments utilized in the experiments at 0.1% level of significance. Compost application consistently showed better results across most growth and yield parameters assessed. Growth parameters included plant height, leaf count per plant, leaf length, and leaf width, while yield parameters included beetroot diameter, beetroot length, root yield, and leaf yield. Organic compost manure particularly stood out, displaying significantly larger beetroot diameter (4.85 cm) and greater beetroot length (9.3 cm). Additionally, compost manure led to notably increased root yield (13.95 t/ha) compared to the control treatment, which recorded a lower root yield (6.28 t/ha). Overall, all treatments outperformed the control in terms of growth and yield parameters. These findings suggest that organic compost manure is the most favorable choice for achieving high-quality beetroot production in the hilly regions of Nepal.
Keywords: Beetroot, Organic fertilizers, Synthetic fertilizers, Yield enhancement, Soil fertilit

INTRODUCTION

Beetroot (*Beta vulgaris* L.), also known as garden beet or table beet, is a prominent root vegetable that falls within the Chenopodiaceae family, sharing this botanical lineage with vegetables like spinach, Swiss chard, parsley, and celery. It has a chromosome count of 2n = 18. Beetroot's cultivation for human and animal consumption was first documented in Western Europe and North Africa (Kumar et al., 2022). This crop exhibits rapid growth, high productivity, and generally remains unscathed by pests and diseases. Although it is traditionally considered a cool-season crop, beetroot thrives in warmer climates, allowing for winter cultivation in the plains of Nepal. Nevertheless, the growth, development, and yield of beetroot are heavily influenced by soil conditions (Sapkota et al., 2021). The optimal growth temperature falls within the range of 12-19°C, with a soil temperature above 7°C required for germination. The ideal pH for successful beetroot cultivation ranges from 6.0 to 8.0. Beetroot thrives in deep, well-drained, sandy loam to silt loam soils (Kumar et al., 2022).

Initially, *Beta vulgaris* was valued for its leaves and the fleshy elongated midribs that characterize chard (Nottingham, 2004). Beetroot is a nutritional powerhouse, rich in fiber, folate (vitamin B9), manganese, potassium, iron, and vitamin C (Kumar et al., 2022; Adaora et al., 2022). The application of organic manures, such as goat manure, vermicompost, farmyard manure (FYM), and compost, enhances soil water retention and supplies both macro and micro nutrients for improved crop yield (Biondo et al., 2014). In recent times, there has been an increasing inclination towards the use of natural fertilizers like Farmyard Manure (FYM), Vermicompost, Poultry manure, Neem cake, and Goat manure to enhance crop productivity and sustain soil health, as observed by Yadav et al. (2023a). Apart from nutrient requirements, the yield of beetroot is influenced by the genetic characteristics of the chosen variety. The selection of the variety should be tailored to the local growing conditions and the season (Kumar et al., 2022). Whereas, inorganic fertilizers release nutrients quickly, making them a popular choice among farmers to provide nutrients for vegetable crops and achieve high yields. However, excessive use of these fertilizers can pose risks to human health, lead to nutrient loss, contaminate groundwater, and reduce the effectiveness of microbial communities in the soil.

Research on beetroot cultivation has been conducted extensively in various parts of the world, including our own country. These studies have underscored the benefits of utilizing both organic and inorganic fertilizers in beetroot farming. Hussain and Kerketta (2023) have noted that organic fertilizers like compost and goat manure enhance soil fertility, boost nutrient availability, and stimulate microbial activity. Numerous greenhouse experiments have consistently shown that vermicompost can have positive effects on plant germination, growth, yield, and overall quality. Mbithi (2021) observed increased seedling emergence when vermicompost was used across a wide range of test plants, including pea, lettuce, wheat, cabbage, tomato, and radish. Addo (2021) found that vermicompost led to higher seedling emergence compared to control commercial plant growth media. Furthermore, Biondo et al. (2014) reported that the optimal use of fertilizers results in higher yields and improved crop quality. Among these fertilizers, nitrogen has emerged as a critical factor influencing vegetable yield and chemical composition, particularly in relation to nitrate content. Therefore, a judicious application of nitrogen can positively impact beetroot growth and yield characteristics. Rantao (2013) also noted that a balanced supply of phosphorus and potassium contributes to increased sugar and starch content in crops, while secondary and micronutrients play pivotal roles in enhancing crop quality.

Kumar et al. (2022) emphasized the need to fine-tune fertilizer application rates for beetroot across different environmental conditions. Furthermore, they noted that organic manure fertilizers typically lead to enhancements in soil physical and chemical properties, improved plant nutrition, better vegetative growth, and increased qualitative and quantitative attributes in vegetable crops. Shafeek et al. (2019) observed that elevating the levels of organic manure fertilizers results in improved plant growth characteristics, potentially leading to an increase in the nutritional elements available within the rooting zone of beetroot plants. This heightened availability of nutrients, particularly N (nitrogen), P (phosphorus), K (potassium), Zn (zinc), Fe (iron), and Mn (manganese), is notable even from the early stages of crop growth. Nitrogen, a key component of NPK, holds significant importance as a crucial nutrient for plant growth, exerting a substantial influence on crop development and yield, as emphasized by Mandal et al. (2023). Though, Katel et al. (2023) discovered that excessive application of NPK can result in a decline in crop productivity. Furthermore, Yadav et al. (2022a) indicated that the excessive utilization of manure such as poultry manure can lead to the contamination of crops, soil, or water sources. Devi et al. (2016) reported that the utilization of organic manures like farmyard manure (FYM), vermicompost, compost, and goat manure serves to enhance and ameliorate soil health, as well as positively impact the growth and yield of various crops. Moreover, as noted by Yadav et al. (2023b), the role of soil biota in enhancing soil quality, bolstering plant vitality, and fortifying soil resilience is paramount. Additionally, the existence of beneficial microorganisms is crucial for sustaining soil fertility, boosting plant resilience, and fostering overall crop well-being (Yadav et al., 2023c). This approach aligns with the broader objective of sustainable agricultural production and promotes the eco-friendly recycling of nutrients.

Generally, beetroot cultivation is done in open field in late winter spring in traditional manner. Nowadays, beetroots are gaining more importance due to their many positive nutritional and physiological properties. The total area occupied by beetroot cultivation is around 5.9 million hectares worldwide, resulting in an estimated total production of 240 million tons. On the other hand, fodder beet provides only 10 million tons for animal feeding. The major beetroot producing countries are Russia, the United States, Germany, France, Turkey and Poland.

In vegetable farming, especially in hilly areas like Khotang, numerous challenges exist. Primary concerns include the lack of irrigation, limited market access, climate change impacts, and outdated farming practices. In the case of beetroot cultivation in Khotang, specific issues include a lack of knowledge, inadequate fertilizers, low-yielding varieties, disease pests, storage problems, and traditional farming practices. In Nepal, only one variety, "Madhur," is officially registered, while other varieties like "Ruby Red" and "Ruby Queen" are imported from abroad and distributed by private companies (Sapkota et al., 2021). To revitalize beetroot farming and enhance agricultural sustainability, addressing these challenges by improving irrigation, market access, farming techniques, knowledge dissemination, and promoting high-yielding varieties is crucial.

Therefore, this study aims to enhance beetroot crop productivity and quality through the effective use of organic and inorganic fertilizers. By promoting awareness among farmers and improving support systems, this research seeks to optimize beetroot production in Khotang district. The expected outcomes include increased economic returns for farmers and improved living standards. This study addresses various challenges in beetroot production and marketing, providing practical solutions and generating valuable evidence-based information. This data benefits not only researchers and students but also governmental bodies like PMAMP and AKC, contributing to agricultural advancement, livelihood improvement, and sustainable development in Khotang and beyond.

MATERIALS AND METHODS

Research site

The study site, located in Khotang district within the hilly terrain of Koshi Province, Eastern Nepal, possesses central geographic coordinates approximately at 27°11′60″ N latitude and 86°46′59.99″ E longitude, spanning an altitude gradient from 152 to 3652 meters above sea level (masl), as depicted in Figure 1. Majhuwagadhi, Diktel, was selected as the focal point of investigation owing to its favorable agroclimatic attributes and soil characteristics conducive to vegetable cultivation. The research site, located in Diktel Rupakot Majhuwagadhi Municipality Ward No. 1, was chosen for vegetable farming due to its favorable climate and soil conditions. It's within the vegetable zone designated by PMAMP and known for cooperative farmers. The district is renowned for tomato production, serving as a supplier to neighboring villages.

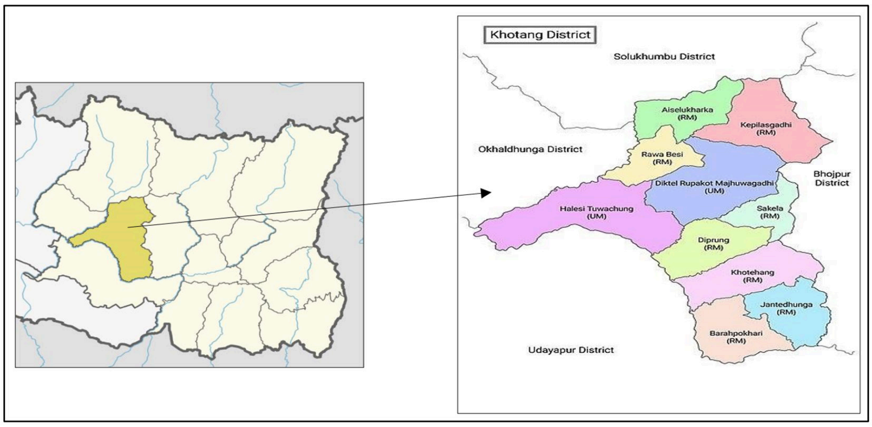

Figure 1. Map of Research site

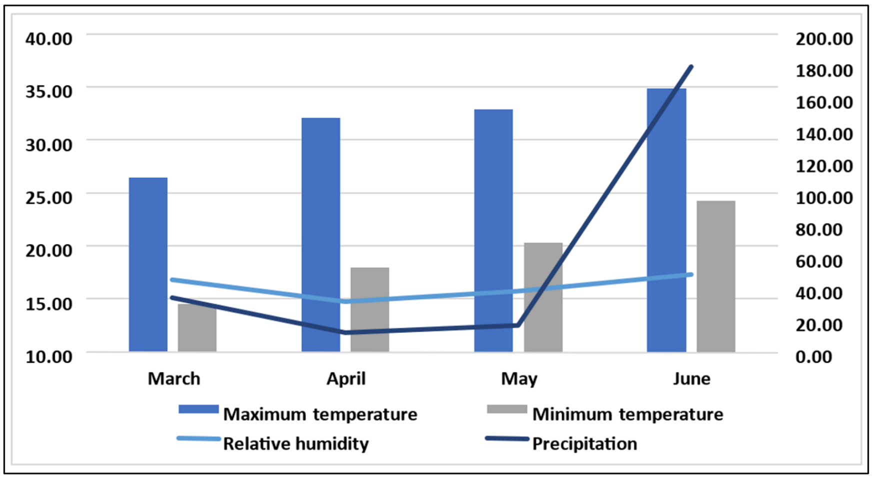

Figure 2. Meteorological data from sowing to harvesting

Research design

In this investigation, a randomized complete block design (RCBD) was utilized, comprising five distinct treatments replicated four times (Yadav et al., 2022b). The treatments included T1: 100% Compost at a rate of 20 tons per hectare, T2: 100% Vermicompost at a rate of 5 tons per hectare, T3: 100% Goat manure at a rate of 10 tons per hectare, T4: 100% NPK fertilizer at a rate of 120:80:40 kg per hectare, and T5: Control, where no recommended doses of organic manures or inorganic fertilizers were applied. The research area measured 12 meters in length and 5.90 meters in width, with each plot covering 1.53 square meters. A total of 20 plots were established with a spacing of 0.5 meters between treatments and replications. Plant-to-plant spacing was set at 10 centimeters, resulting in 42 plants per plot.

Varietal details

In Nepal, the only registered beetroot variety is Madhur, which was released in 2010 AD. This variety exhibits a broad adaptability range and demonstrates excellent field-holding capacity. The foliage is characterized by a medium, dull green color with a maroon tinge. Madhur boasts strong plant vigor, producing dark red and round roots, which maintain their proper shape even when plants are closely spaced. It is cultivated during the winter season in the plains and as a spring-summer crop in the hilly regions of Nepal. Madhur also thrives in warm weather conditions due to its adaptive capabilities.

Cultivation practices

The land preparation involved two ploughing sessions, with the initial ploughing taking place 15 days before sowing and the application of FYM at a rate of 20 tons/ha. Subsequently, one week prior to sowing, a mini-tiller machine was used to further till the soil, ensuring it was in good condition. The field was then leveled, and any stubbles, plant debris from previous crops, and weeds were removed. For manure and fertilizer application, FYM served as the primary source of organic fertilizer. Compost manure was applied at a rate of 20 tons/ha, vermicompost at 5 tons/ha, Goat manure at 10 tons/ha, and NPK at 120:80:40 kg/ha. These were uniformly incorporated into the soil after the final land preparation and before sowing to the deginated plots. Seed sowing was carried out manually, with germination observed seven days after sowing. Two seeds per hill were sown in rows on March 14, 2023, with a spacing of 20 × 10 cm. The soil was irrigated one day before sowing to loosen it for better germination. After germination, irrigation was provided once a week or at 3–4day intervals as required. Weeding was done manually by hand weeding at 20, 40, and 60 days after sowing, while thinning was performed manually when the seedlings reached a height of 7.5 cm. Harvesting took place manually through hand-picking, occurring at 85 days after sowing (DAS).

Observation and data collection

For data collection, a set of eight random plants were selected for observation and measurement from each plot. It is important to note that the border plants were excluded to ensure that the data collected was representative of the interior of the plots and not influenced by border effect. During the crop growing period, several key parameters were recorded. This included plant height (cm), number of leaves per plant, leaf length (cm), and leaf breadth (cm). These measurements provided insights into the growth and development of the beetroot plants throughout their growth cycle. After the harvesting stage, additional parameters were measured to assess the yield parameters. These included root diameter (cm), root length (cm), root yield (t/ha), and leaf yield (t/ha).

Statistical analysis

The data collected from the experiment were inputted into Microsoft Excel (2019) and analyzed using R-studio software (4.2.2 Version). To compare the means of the parametric data, the Duncan Multiple Range Test (DMRT) was used as a statistical method (Gomez & Gomez, 1984).

RESULTS AND DISCUSSION

The ANOVA examination demonstrated a significant impact of organic fertilizers on beetroot plant height across various growth stages ($p \leq 0.05$) (Table 1 and Table 2). Particularly, compost consistently promoted the greatest plant height from 50 days post-sowing until the culmination of the growth period. At harvest, plants treated with compost displayed significantly greater height (38.30 cm) in comparison to those under the control treatment (30.26 cm) ($p \leq 0.01$). Moreover, at harvest, vermicompost application resulted in a significantly higher leaf count (12.27) compared to the NPK treatment, which yielded fewer leaves (10.20) ($p \leq 0.001$) (Table 1 and Table 2). These findings underscore agricultural practices conducive to augmenting crop productivity. Similarly, compost consistently induced significantly elongated leaves compared to other fertilization sources (Table 3 and Table 4). Conversely, the control treatment led to substantially shorter leaves, averaging 27.37 cm. Katel et al. (2021) discovered that super combined fertilizer releases its active components gradually, a trait that offers advantages in the agricultural domain. Furthermore, the ANOVA analysis unveiled that compost consistently induced broader beetroot leaves in comparison to alternative sources, with statistically significant discrepancies ($p \leq 0.05$) (Table 3 and Table 4). This pattern persisted from 30 days post-sowing until the final harvest. Conversely, leaves from the control treatment exhibited significantly narrower dimensions, measuring merely 7.62 cm ($p \leq 0.05$). Likewise, the ANOVA analysis in Table 5 shows that the root diameter of beetroot was significantly influenced by organic and inorganic sources, especially at harvest. Compost had the largest average root diameter at 4.85 cm ($p \leq 0.05$), while the control treatment had the smallest at 2.35 cm. Table 5 also reveals that Beetroot length was notably affected by organic and inorganic sources, particularly at harvest. Compost resulted in the longest beetroot length, measuring an impressive 9.3 cm ($p \leq 0.001$), while the control treatment had the shortest length at 6.4 cm. Regarding root yield, Table 5 demonstrates that it was significantly affected by the choice of organic and inorganic sources. Compost led to the highest root yield at 13.95 tons per hectare (t/ha) ($p \leq 0.01$), while the control treatment had the lowest yield at 6.28 t/ha. Table 5 also details the impact of organic and inorganic sources on leaf yield. The ANOVA analysis shows that leaf yield was significantly affected by the choice of sources. NPK treatment resulted in the highest leaf yield at 11.09 t/ha ($p \leq 0.01$), while the control treatment had the lowest yield at 5.75 t/ha. Furthermore, both Adhikari et al. (2023) and Sangam et al. (2023) observed that organic fertilizers hold considerable potential for enhancing crop productivity. Hence, the utilization of Goat manure alongside NPK resulted in improved yield production, aligning partially with the aforementioned research findings.

The results unequivocally indicate that the application of organic fertilizers had a profoundly positive influence on various vegetative parameters of beetroot. Among the various organic fertilizers tested, plants that received vermicompost displayed the highest number of leaves per plant, followed by those treated with compost manure, while the control group exhibited the lowest leaf count (Rantao, 2013). This might be due to organic fertilizers, particularly vermicompost and compost manure, enhanced beetroot vegetative parameters, likely due to nutrient-rich soil enrichment. Similarly, the compost treatment surpassed the other methods in several aspects, leading to significantly greater plant height, longer leaves, and wider leaves when compared to alternative treatments. These findings align with the conclusions drawn by Ajari et al. (2003) and Kumari et al. (2022), highlighting the significant benefits of using organic fertilizers vermicompost and compost in particular to promote the vegetative growth and development of beetroot plants, which in turn improves crop quality and production. Moreover, the significant rise in root diameter and length noted in the group treated with compost was a direct cause of the increased root production attained in the same treatment. This phenomenon can be attributed to various factors associated with the utilization of compost manure. Primarily, the extended root length in plots treated with compost can be attributed to the presence of phosphorus, which was present at a substantial level (0.96%) in the compost manure. Phosphorus plays a pivotal role in stimulating root growth, facilitating enhanced nutrient absorption and translocation within the plant (Addo, 2021). It is also an essential component of various enzymes and energy-rich ATP, resulting in root growth (Kumar & Venkatasubbaiah, 2016). Clark et al. (1998) demonstrated that compost-amended soils exhibit elevated phosphorus levels, attributing this phenomenon to the organic matter's phosphorus enrichment. Concurrently, the application of organic manures like compost fosters a conducive microbial environment within the soil. These soil microorganisms play a pivotal role in synthesizing polysaccharides, thereby improving soil structure, which subsequently facilitates enhanced root growth (Balasubramanian et al., 1972). Moreover, the discernible augmentation in root diameter observed in compost-treated plots can be elucidated by the abundant availability of phosphorus from compost manure. Phosphorus, recognized for its pivotal role in facilitating metabolic processes within plants, exerts a pronounced influence on root diameter, particularly in root crops. This aligns with the findings of Kanauija (2013) and Jagadeesh et al. (2018), who documented increased root diameter in carrot crops following the application of a blend of urea and organic manure. The consequential increase in root diameter under compost treatment directly translates to amplified root yield within the same treatment. This cumulative effect underscores the interplay between improved growth and yield characteristics. Additionally, the heightened root yield can be ascribed to the utilization of organic fertilizers, which mitigate nutrient losses, enhance nutrient utilization efficiency, and augment soil nutrient availability, thereby culminating in amplified root yields (Rantao, 2013). Overall, this mechanistic understanding highlights the intricate interactions between soil enrichment, microbial activity, nutrient availability, and crop yield in the context of organic fertilizer application. It's imperative to acknowledge that the biological yield of plants is influenced by multiple factors, including leaf characteristics and root parameters. The combined use of inorganic fertilizers and organic manure enhances soil nutrient availability, particularly nitrogen, thus augmenting plant biological yield. These findings corroborate similar research outcomes, such as those presented by Subedi et al. (2018) & Sintayehu et al. (2022) in radish cultivation. Our study revealed that plots treated with organic fertilizers exhibited superior yield and growth metrics compared to those treated solely with inorganic counterparts. Thus, the notion that organic farming yields are inherently lower is unfounded based on our empirical evidence (Avery, 1995) & Pokharel et al. (2023). Our results unequivocally demonstrate that organic fertilizers can improve soil biological, chemical, and physical properties relative to inorganic alternatives, leading to enhanced crop productivity.

Table 1. Effect of organic and inorganic fertilizers on plant height and leaves per plant at different stages of Beetroot.

Treatments	Plant height (cm)					
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	85 DAS
Compost	7.37[a]	12.95[a]	23.10[a]	28.55[a]	33.37[a]	38.30[a]
Vermicompost	7.25[a]	12.47[ab]	21.30[ab]	27.70[a]	31.25[a]	32.72[b]
Goat manure	6.67[a]	11.50[abc]	19.57[abc]	26.92[a]	31.12[a]	32.70[b]
NPK	6.00[a]	9.30[c]	16.25[c]	21.75[b]	28.67[a]	30.82[b]
Control	6.52[a]	10.22[bc]	17.95[bc]	23.62[ab]	28.52[a]	30.26[b]
Grand mean	6.765	11.29	19.635	25.71	30.59	32.963
CV (%)	15.77	13.10	11.76	12.37	10.79	7.10
SEM (±)	0.55	1.04	1.72	1.91	1.63	1.82
F test	NS	*	**	*	NS	**

NPK: Nitrogen, Phosphorus, and Potassium; FYM: Farm Yard Manure; CV: Coefficient of Variation; SEM: Significant error of Mean; *Significant at 5% level of significance, **Significant at 1% level of significance, ***Significant at 0.1% level of significance, [NS]Non-significant

Table 2. Effect of organic and inorganic fertilizers on plant height and leaves per plant at different stages of Beetroot.

Treatments	Number of leaves per plant					
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	85 DAS
Compost	5.82[ab]	7.20[ab]	8.87[ab]	10.07[a]	11.05[a]	11.80[ab]
Vermicompost	6.35[a]	7.60[a]	9.57[a]	10.77[a]	11.62[a]	12.27[a]
Goat manure	5.27[b]	6.40[b]	8.35[b]	9.55[ab]	10.47[a]	11.02[bc]
NPK	3.57[c]	4.90[c]	6.97[c]	8.52[bc]	10.37[a]	10.20[c]
Control	3.40[c]	4.92[c]	6.82[c]	7.65[c]	8.70[b]	11.30[ab]
Grand mean	4.88	6.20	8.12	9.31	10.44	11.32
CV (%)	12.87	9.71	8.02	9.72	10.06	5.86
SEM (±)	0.67	0.64	0.61	0.69	0.68	0.50
F test	***	***	***	**	*	**

NPK: Nitrogen, Phosphorus, and Potassium; FYM: Farm Yard Manure; CV: Coefficient of Variation; SEM: Significant error of Mean; *Significant at 5% level of significance, **Significant at 1% level of significance, ***Significant at 0.1% level of significance, [NS]Non-significant

Table 3. Effect of organic and inorganic fertilizers on leaf length and leaf breadth at different stages of Beetroot.

Treatments	Leaf length (cm)					
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	85 DAS
Compost	7.35[a]	12.45[a]	21.67[a]	28.02[a]	32.80[a]	34.77[a]
Vermicompost	6.77[a]	12.00[a]	20.80[ab]	28.07[a]	30.72[a]	31.55[ab]
Goat manure	6.67[a]	11.30[a]	19.75[ab]	26.37[ab]	30.40[a]	31.62[ab]
NPK	5.05[a]	9.22[a]	15.62[b]	21.22[b]	28.12[a]	30.42[ab]
Control	5.02[a]	8.65[a]	16.02[b]	22.02[b]	26.57[a]	27.37[b]
Grand mean	6.175	10.725	18.775	25.145	29.725	31.15
CV (%)	23.07	21.98	17.05	14.34	12.74	10.75
SEM (±)	0.86	1.33	1.95	2.19	1.92	1.94
F test	NS	NS	*	*	NS	*

NPK: Nitrogen, Phosphorus, and Potassium; FYM: Farm Yard Manure; CV: Coefficient of Variation; SEM: Significant error of Mean; *Significant at 5% level of significance, [NS]Non-significant

Table 4. Effect of organic and inorganic fertilizers on leaf length and leaf breadth at different stages of Beetroot.

Treatments	Leaf breadth (cm)					
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	85 DAS
Compost	2.00^{a}	4.05^{a}	5.95^{a}	8.40^{a}	8.12^{a}	10.35^{a}
Vermicompost	1.97^{a}	3.87^{a}	5.45^{ab}	8.45^{a}	9.15^{a}	9.46^{ab}
Goat manure	1.82^{a}	3.67^{a}	5.10^{ab}	8.20^{a}	9.40^{a}	9.45^{ab}
NPK	1.52^{a}	2.72^{a}	4.05^{b}	6.72^{a}	7.92^{a}	8.87^{ab}
Control	1.42^{a}	2.62^{a}	3.80^{b}	6.17^{a}	7.42^{a}	7.62^{b}
Grand mean	1.75	3.39	4.87	7.59	8.40	9.15
CV (%)	24.86	25.32	22.88	21.41	22.59	15.57
SEM (±)	0.25	0.50	0.66	0.84	0.90	0.77
F test	NS	NS	*	NS	NS	NS

NPK: Nitrogen, Phosphorus, and Potassium; FYM: Farm Yard Manure; CV: Coefficient of Variation; SEM: Significant error of Mean; *Significant at 5% level of significance, ^{NS}Non-significant

Table 5. Effect of organic and inorganic fertilizers on Beetroot diameter, Beetroot length, root yield and leaf yield.

Treatments	Root diameter (cm)	Root length (cm)	Root yield (t/ha)	Leaf yield (t/ha)
Compost	4.85^{a}	9.3^{a}	13.95^{a}	7.28^{b}
Vermicompost	3.85^{b}	7.2^{c}	9.16^{c}	7.24^{b}
Goat manure	4.02^{b}	8.0^{b}	10.80^{b}	8.13^{b}
NPK	3.37^{b}	7.2^{c}	8.13^{d}	11.09^{a}
Control	2.35^{c}	6.4^{c}	6.28^{e}	5.75^{c}
Grand mean	3.69	7.62	9.66	7.90
CV (%)	12.92	6.57	5.70	10.44
SEM (±)	0.47	0.54	1.36	0.98
F test	***	***	***	***

NPK: Nitrogen, Phosphorus, and Potassium; FYM: Farm Yard Manure; CV: Coefficient of Variation; SEM: Significant error of Mean; ***Significant at 0.1% level of significance

CONCLUSION

The experiment conducted in Khotang district provides valuable insights into the impact of various organic and inorganic fertilizers on different parameters related to beetroot cultivation. Based on our study, it is evident that organic manure consistently outperformed other treatments in terms of overall growth and yield attributes. Our findings indicated that the application of organic manure alone can yield superior results compared to other approaches. This suggests that for optimal beetroot production in the hilly regions of Nepal, the use of organic sources, particularly compost, is highly recommended. It is important to recognize that the applicability of these findings may vary in different agroclimatic locations and with different beetroot varieties. Therefore, further researches are warranted across various regions of the country, encompassing different varieties and additional attributing characteristics, before widespread adoption of these recommendations. This study serves as a valuable contribution to the knowledge base of beetroot cultivation in Nepal, offering insights that can potentially enhance agricultural practices and contribute to food security and livelihood improvement in that region.

Compliance with Ethical Standards

Peer-review

Externally peer-reviewed.

Conflict of interest

The authors state there is no competing interest.

Author contribution

Conceived & designed the experiment, Soni Kumari Majhi, Sunny Kumar Shah & Umesh Timilsina; Performed the experiment, Soni Kumari Majhi, Dipika Kumari Shah, Pratima Chaudhary & Prakash Rijal; Writing- original draft, Soni Kumari Majhi & Dipesh Kumar Mehata; Writing- review & editing, Umesh Timilsina, Dipesh Kumar Mehata & Nand Kishor Yadav; Data curation, Formal data analysis & Visualization of the data, Dipesh Kumar Mehata; Supervision, Sunny Kumar Shah & Umesh Timilsina.

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Data availability

Data will be made availabale on request.

Consent to participate

The authors consent to participate.

Consent for publication

The authors consent for publication.

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