RJOAS: Russian Journal of Agricultural and Socio-Economic Sciences
ISSN 2226-1184 (Online) | Issue 3(147), March 2024

UDC 633

EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON MORPHOLOGICAL AND YIELD CHARACTERISTICS OF CARROT (DAUCUS CAROTA) CV. NEW KURODA IN KHOTANG DISTRICT, NEPAL

Dipika Kumari Sah, **Dipesh Kumar Mehata***, **Bishnu Yadav**,
Soni Kumari Majhi, **Prashamsa Kafle**
Faculty of Science and Technology, G.P. Koirala College of Agriculture and Research Centre, Purbanchal University, Gothgaun, Morang, Nepal

Biplov Oli
Department of Soil Science, College of Natural Resource Management, Agriculture and Forestry University, Bardibas, Nepal

*E-mail: mehatadipesh643@gmail.com

ABSTRACT
An investigation was carried out in Diktel Rupakot Majhuwagadi Municipality, Matikore, Khotang. The aim was to evaluate how both organic and inorganic fertilizers influence the growth and yield traits of the New Kuroda carrot variety. The study utilized a Randomized Completely Block Design with seven treatments, including Control (T1), compost manure + Boron (T2) at 20 t/ha, poultry manure + Boron (T3) at 6 t/ha, vermicompost + Boron (T4) at 4 t/ha, NPK + Boron (T5) at 100:100:100 Kg/ha, neem cake + Boron (T6) at 5 t/ha, goat manure + Boron (T7) at 15 t/ha, and Borax at 10 kg/ha, replicated thrice. The results showed a significant impact of both organic and inorganic fertilizers on all growth and yield parameters. The tallest plants were observed in the compost manure + Boron treatment, followed by goat manure + Boron, whereas the Control had the shortest plants. Importantly, notable differences in yield parameters were noted among the treatments at 100 days after sowing (DAS). The highest root yield per plot was achieved with compost manure + Boron, indicating its superiority, followed by goat manure + Boron, whereas the Control had the lowest yield. This research suggests the use of organic manures to effectively enhance carrot yield.

KEY WORDS
Boron, carrot, fertilizers, growth, yield.

Carrots (*Daucus carota*) represent a primary vegetable crop cultivated globally, originating in Asia, and classified under the family Umbelliferae, genus *Daucus*, and species *carota*. Most cultivated carrots are diploid with a chromosome count of 2n=18 (X=9). Considered an annual crop for root development and biennial for seed production, carrots are valued for their rich nutritional content, providing carotene, thiamin, riboflavin, iron, calcium, minerals, and phosphorus essential for both sustenance and health (Sikora et al., 2020; Singh & Bahadur, 2015). Beyond their nutritional significance, carrot foliage serves as fodder for animals. Carotene extracted from carrots finds application in colouring margarine and enhancing the colour of egg yolks in layer feed (Dawuda et al., 2011). The fleshy roots of carrots are versatile, used in salads, cooked dishes like soups, stews, and curries, as well as for making pickles, jam, halwa, juice, and sweet dishes. Apart from their culinary utility, carrots boast medicinal properties (Afrin et al., 2019). Anthocyanins recognized antioxidants, contribute to the dark or purple colouration of carrots, leading to the production of roots in various hues such as red, orange, yellow, purple, black, and white (Chrong et al., 2007; Raees-ul & Prasad, 2015). Carrots exhibit cross-pollination, attributed to the natural occurrence of protandry, where the male stamen matures before the female pistil (Chaoudhary et al., 2017). In Khotang, the total carrot cultivation area encompasses 5 hectares, yielding 50 metric tons of fresh carrots with a productivity rate of 10.01 metric tons per hectare (MoAD, 2020/21).

In recent times, the adoption of organic fertilizers, including Farmyard Manure (FYM), Vermicompost, Poultry manure, Neem cake, and Goat manure, has been on the rise as a strategy to enhance crop productivity and sustain soil fertility (Yadav et al., 2023a). FYM, recognized for its eco-friendly nature, plays a role in maintaining soil health and improving crop yield by boosting soil fertility (Raj et al., 2014). NPK, especially nitrogen is an essential nutrient for plant growth and plays a critical role in crop development and yield (Mandal et al., 2023). Vermicompost, essential organic manure, contains both macro and micro-nutrients, along with vitamins, growth hormones, and enzymes, contributing to long-term sustainability and supporting crop productivity. Neem cake, known for its rapid action and insolubility in water, provides gradual nourishment, improves soil structure, enhances water retention, guards against nematodes, and enhances overall yield and produce quality (Yousuf Ali et al., 2016). Additionally, neem seed cake fosters earthworm populations and produces organic acids, aiding in reducing soil alkalinity (Korah and Shingte, 1968). Further, Yadav et al. (2023b) reported that the vital role of soil biota in enhancing soil quality, promoting plant health, and bolstering soil resilience cannot be overstated. Moreover, the abundance of beneficial microorganisms is crucial for sustaining soil fertility, bolstering plant resilience, and fostering general crop well-being (Yadav et al., 2023c). According to Soon and Bottrel (1994), neem cake serves as a natural fertilizer with inherent pesticide properties, containing higher nitrogen (2-5%), phosphorous (0.5-1%), calcium (0.5-3%), and magnesium (0.3-1%) compared to FYM (Eifediyi, 2015). Goat manure, on the other hand, contributes balanced nutrition, supporting robust root development and improving carrot quality. While inorganic fertilizers provide quick nutrient delivery to meet immediate crop needs, organic fertilizers release nutrients gradually, promoting healthy plant growth. Excessive nitrogen in fertilizers can lead to splitting, emphasizing the need for efficient nitrogen uptake through proper watering to maintain carrot quality. Whereas, Katel et al. (2023) reported that the excess utilization of NPK can also reduce the crop productivity. Further, poultry manure can contribute to the contamination of crops, soil or water if utilized in excess amount (Yadav et al., 2022a). Research indicates that optimal growth and yield of carrots are achieved with a nitrogen application of 100 kg/ha. Maintaining a balance between chemical and organic fertilizers is crucial for carrot growth. Excessive reliance on chemical fertilizers can degrade soil quality, highlighting the importance of a standardized approach to fertilizer application (Afrin et al., 2019). The combined use of organic and inorganic fertilizers not only reduces soil erosion but also enhances water infiltration, soil aeration, and plant root growth, minimizing the risk of downstream flooding (Kushwaha et al., 2019). Katel et al. (2021) reported that super combined fertilizer releases active ingredients slowly which is beneficial in the agricultural sector. Our agricultural system depends on both macronutrients and micronutrients, but due to the illiteracy and ignorance of our farmers, micronutrients that are diminishing in the soil are often overlooked (Sultana et al., 2015). Boron (B) is an essential element for the formation of meristems and the metabolism of sugars. However, a pH of 6.2 in the soil increases the likelihood of widespread boron shortage, especially on sandy soils during a rainy period (Subba et al., 2017).

This study aims to investigate the effects of organic and inorganic fertilizers on the morphological and yield characteristics of carrots in Khotang, Nepal. The decision to focus on one-year data was made to ensure a precise and comprehensive analysis within a responsible timeframe. Additionally, this approach allows for an in-depth understanding of initial outcomes before longer-term trends emerge, thereby providing a solid foundation for future research and discussion. It's worth noting that this study represents the first research conducted in this specific field in Nepal, which further underscores the importance of our findings in guiding future research.

MATERIALS AND METHODS OF RESEARCH

The experiment was carried out at Matikore-1, Khotang, from April 2023 to June 2023. The area is at 27°11′60 ″ N latitude & 86°46′59.99″ E longitude and elevation of about 152 to

3652 masl. The climate of the experimental area was subtropical. The meteorological data of the research site throughout the study period is presented in Figure 1.

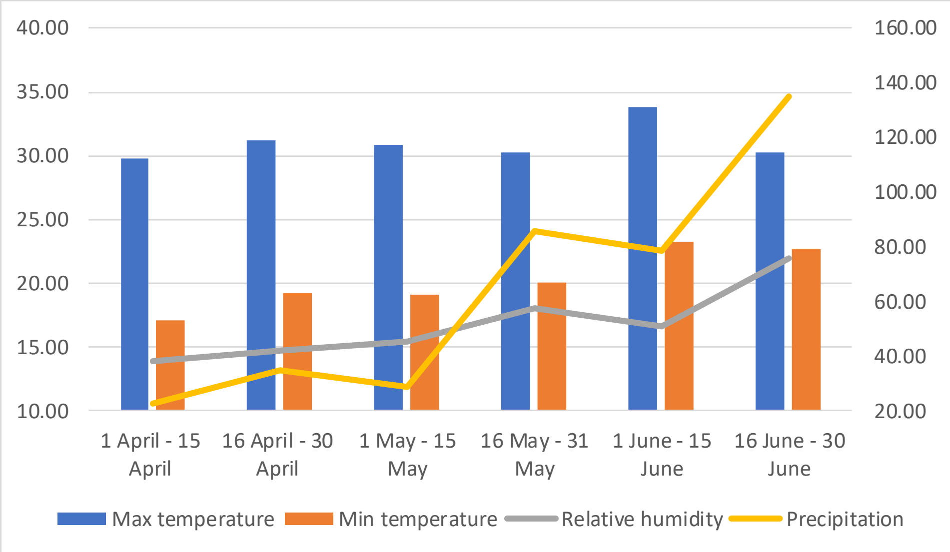

Figure 1 – Meteorological data of the research site throughout the study period

The research focused on varietal selection in carrot cultivation, with specific emphasis on the New Kuroda variety to evaluate the vegetative and reproductive characteristics under the influence of different organic and inorganic fertilizers.

The study employed a Randomized Completely Block Design featuring seven treatments: Control (T1), compost manure + Boron (T2) @20 t/ha, Poultry manure + Boron (T3) @6 t/ha, Vermicompost + Boron (T4) @4 t/ha, NPK + Boron (T5) @100:100:100 Kg/ha, Neem cake + Boron (T6) @5 t/ha, Goat manure + Boron (T7) @15t/ha, and Borax @10 kg/ha. This design, replicated thrice, involved random allocation of treatments within blocks (Yadav et al., 2022b). Twenty-one plots, sized 1.8m x 1m and spaced 0.5m apart, were prepared. Two weeks before seed sowing, the field was tilled using a mini tiller, followed by levelling and removal of previous crop remnants and weeds. Application of organic and inorganic fertilizers occurred during land preparation. In mid-February, soaked carrot seeds were sown at 20x10 cm spacing. Thinning, weeding, and light irrigation post-sowing were conducted. Manual harvesting involved gently pulling carrots from the soil. Pest control and irrigation measures were implemented to ensure optimal crop health and development.

Data collection employed the direct observation method, with plant characteristics and yield metrics recorded on ten randomly chosen plants for each treatment. The assessment covered twelve parameters, including plant height, leaf traits, root dimensions, and yield metrics. Recording of vegetative parameters commenced 40 days after sowing and persisted at 20-day intervals until harvest. Yield parameters were documented at both 100 and 120 days after sowing (DAS). The observational approach ensured a comprehensive evaluation of the crop's development, capturing key aspects from early growth to the later stages of plant maturity.

Data input for both replication and treatment blocks followed a chronological order using MS Excel 2021 (Microsoft Corporation, Washington, USA). Subsequently, statistical analysis was conducted using R Studio (Version 4.2.2, Boston, Massachusetts, USA) to perform an analysis of variance (ANOVA). For comparison of mean values among various treatments, Duncan's Multiple Range Test (DMRT) was applied, with a significance level set at 5% (Gomez & Gomez, 1984).

RESULTS AND DISCUSSION

Significant variations were observed among different treatments in terms of plant height, with the maximum height recorded in the Compost manure + Boron treatment at 40, 60, 80, 100, and 120 days after sowing (DAS) being 7.78, 18.92, 41.61, 55.48, and 62.79 cm, respectively. Following closely was the Goat manure + Boron treatment, exhibiting plant heights of 6.37, 16.35, 34.71, 46.62, and 54.88 cm at the respective DAS intervals. Comparatively, a study by Afrin et al. (2019) on carrot growth and yield influenced by organic and inorganic fertilizers showed slightly lower results than the present findings, with vermicompost treatments yielding plant heights ranging from 43 to 47 cm. This variance could be attributed to factors such as fertilizer dosage, environmental conditions, variety selection, and genetic factors. Furthermore, the inclusion of boron in the treatments may have contributed to the enhanced plant height observed in the current study. Conversely, the control group exhibited the minimum plant height at 40, 60, 80, 100, and 120 DAS, measuring 3.56, 8.63, 14.95, 23.32, and 26.73 cm, respectively, aligning with findings from previous studies. The diminished height in the control group is attributed to a lack of nutrient supply, hindering optimal growth due to the absence of essential elements necessary for plant health. The statistical analysis revealed highly significant differences (at the 0.1% level) in plant height among treatments throughout the research period, with the mean plant height at harvest being 45.51 cm.

Table 1 – Effect of organic and inorganic fertilizers on plant height (cm)

Treatment	Plant height (cm)				
	40 DAS	60 DAS	80 DAS	100 DAS	120 DAS
Control	3.56[d]	8.63[c]	14.95[c]	23.32[d]	26.73[d]
Compost manure + Boron	7.78[a]	18.92[a]	41.61[a]	55.48[a]	62.79[a]
Poultry manure + Boron	5.64[bc]	15.09[b]	28.11[b]	39.53[c]	43.78[c]
Vermi compost + Boron	5.26[c]	13.24[b]	30.67[b]	40.07[c]	43.67[c]
NPK + Boron	5.39[bc]	13.69[b]	27.32[b]	35.59[c]	40.83[c]
Neem cake + Boron	5.55[bc]	13.30[b]	28.42[b]	39.74[c]	45.87c
Goat manure + Boron	6.37[b]	16.35[ab]	34.71[ab]	46.62[b]	54.88[b]
Grand mean	5.65	14.17	29.40	40.05	45.51
SEM (±)	0.12	0.41	0.93	0.68	0.69
CV (%)	9.66	13.09	14.41	7.81	6.94
F- test	***	***	***	***	***

*Note: *** represents 0.1% level of significance, DAS: Days after sowing, CV: Coefficient of variance.*

There were significant differences ($p<0.1$) observed among the various treatments concerning the number of leaves per plant. Compost manure + Boron exhibited the highest number of leaves per plant at different stages (2.73, 5.77, 10.53, 13.07 & 14.60) at 40, 60, 80, 100, and 120 days after sowing (DAS), respectively. Following closely was Goat manure + Boron, showing substantial leaf numbers (2.30, 4.90, 8.07, 10.6 & 11.57) at the corresponding DAS. These results surpassed those reported in a previous study by Kiran et al. (2022), where the highest recorded number of leaves with organic manure was around 9. The superior outcomes can be attributed to the combined effects of fertilizer dosage and boron application, significantly enhancing leaf number, growth, and development. Environmental factors such as temperature, light, and irrigation also played a role. Conversely, the control group exhibited the minimum number of leaves per plant (2.07, 3.47, 5.57, 6.9 & 7.67) at 40, 60, 80, 100, and 120 DAS, respectively. The reduced leaf count in the untreated group is solely attributed to the lack of essential nutrients necessary for proper growth and development. The average number of leaves per plant at harvest was 10.86.

The length of leaves per plant (cm) demonstrated significant variation among the different treatments at a 0.1% level of significance. Compost manure + Boron exhibited the maximum leaf length per plant (6.97, 17.20, 39.79, 53.31 & 60.67 cm) at 40, 60, 80, 100, and 120 days after sowing (DAS), respectively, followed by Goat manure + Boron with lengths of (5.40, 14.97, 31.91, 44.73 & 52.75 cm) at the corresponding DAS. This superior performance can be attributed to the optimal availability of nutrients and the synergistic effects of Compost manure and boron. Although Goat manure + Boron was effective, there might be a deficiency in certain elements, leading to a slightly reduced leaf length. This observation aligns with the findings of a previous study by Paul et al. (2022).

Table 2 – Effect of organic and inorganic fertilizers on number of leaves per plant

Treatment	Number of leaves per plant				
	40 DAS	60 DAS	80 DAS	100 DAS	120 DAS
Control	2.07^{e}	3.47^{e}	5.57^{c}	6.9^{e}	7.67^{d}
Compost manure + Boron	2.73^{a}	5.77^{a}	10.53^{a}	13.07^{a}	14.60^{a}
Poultry manure + Boron	2.27^{bc}	4.67^{bc}	7.83^{b}	10.17^{bc}	11.30^{bc}
Vermi compost + Boron	2.10^{de}	4.17^{cd}	7.17^{b}	9.1^{d}	10.07^{c}
NPK + Boron	2.23^{bcd}	4.30^{cd}	7.23^{b}	8.93^{d}	10.17^{c}
Neem cake + Boron	2.13^{cde}	3.93^{e}	7.53^{b}	9.3c^{d}	10.63^{bc}
Goat manure + Boron	2.30^{b}	4.90^{b}	8.07^{b}	10.6^{b}	11.57^{b}
Grand mean	2.26	4.46	7.71	9.72	10.86
SEM (±)	0.02	0.07	0.93	0.12	0.15
CV (%)	3.76	6.90	7.38	5.80	6.16
F- test	***	***	***	***	***

*Note: *** represents 0.1% level of significance, DAS: Days after sowing, CV: Coefficient of variance.*

The overall mean length of leaves at harvest was 43.38 cm. In contrast, the minimum leaf length per plant (3.32, 7.80, 12.80, 21.31 & 24.50 cm) was observed in the Control group at 40, 60, 80, 100, and 120 DAS, respectively. The Control group displayed minimal leaf length, indicating suboptimal growth conditions without specific treatments. The absence of nutrient supplementation or soil amendments in the Control group may impede plant development, resulting in shorter leaves compared to the treated groups.

Table 3 – Effect of organic and inorganic fertilizers on length of leaves per plant (cm)

Treatment	Length of leaves per plant (cm)				
	40 DAS	60 DAS	80 DAS	100 DAS	120 DAS
Control	3.32^{d}	7.80^{d}	12.80^{c}	21.31^{d}	24.50^{d}
Compost manure + Boron	6.97^{a}	17.20^{a}	39.79^{a}	53.31^{a}	60.67^{a}
Poultry manure + Boron	4.42^{c}	14.19^{bc}	25.94^{b}	37.52^{c}	42.29^{c}
Vermi compost + Boron	4.10^{cd}	12.31^{c}	28.45^{b}	37.89^{c}	41.26^{c}
NPK + Boron	4.15^{cd}	12.66^{bc}	26.01^{b}	33.65^{c}	38.37^{c}
Neem cake + Boron	4.51^{c}	12.54^{bc}	28.05^{b}	37.61^{c}	43.83^{c}
Goat manure + Boron	5.40^{b}	14.97^{ab}	31.91^{b}	44.73^{b}	52.75^{b}
Grand mean	4.70	13.15	27.56	38.00	43.38
SEM (±)	0.10	0.07	0.89	0.70	0.67
CV (%)	9.84	10.29	14.74	8.42	7.08
F- test	***	***	***	***	***

*Note: *** represents 0.1% level of significance, DAS: Days after sowing, CV: Coefficient of variance.*

Significant differences in leaf fresh weight (g) among treatments were evident, with Compost manure + Boron leading at 100 DAS (163g), followed by Goat manure + Boron (94.83g), while Control showed the lowest (40.33g). All treatments significantly enhanced leaf weight ($p<0.1$), with Compost manure + Boron excelling due to synergistic effects and optimal conditions. At 120 DAS, Compost manure + Boron maintained superiority (145.50g), followed by Goat manure + Boron (111.83g), while Control exhibited the minimum (52.83g). The persistent differences emphasize prolonged treatment impact, attributed to sustained nutrient availability and favorable conditions. Compost manure + Boron's sustained effectiveness underscores its role in promoting increased leaf weight, while Goat manure + Boron contributed positively. The Control group's lower leaf weight underscores the treatments' crucial role in fostering robust leaf growth.

Distinct variations in root length were observed across treatments, with Compost manure + Boron displaying the maximum root length (17.83cm). This superior performance is likely attributed to the synergistic effects of Compost manure and Boron, enhancing nutrient absorption and overall root growth. Following closely was Goat manure + Boron, with a root length of 15.13 cm. In comparison, previous research by Paul et al. (2022) and Zakir et al. (2012) reported higher root length (16 cm) with poultry manures alone, surpassing our findings of 12.22 cm with poultry manures and Boron. Discrepancies may arise from climatic conditions, fertilizer dosage, and the variety used in the study. Conversely, the Control group exhibited the minimum root length (8.22cm). The overall mean root length among treatments stood at 12.80 cm, and the results were highly significant at a 0.1% level. This underscores the impact of treatments on root development, with Compost manure + Boron leading to the most substantial root length. The observed variations can be attributed to the combined effects of specific treatments, emphasizing their significance in influencing root growth patterns.

Table 4 – Effect of organic and inorganic fertilizers on Fresh weight of leaves (g)

Treatment	Fresh weight of leaves	
	100 DAS	120 DAS
Control	40.33c	52.83d
Compost manure+ Boron	163a	145.50a
Poultry manure+ Boron	90b	103.33bc
Vermi compost+ Boron	84.83b	92.80bc
NPK + Boron	67.83b	84.33c
Neem cake + Boron	80.33b	94.67bc
Goat manure + Boron	94.83b	111.83b
Grand mean	88.74	97.90
SEM (±)	7.48	2.66
CV (%)	38.65	12.44
F- test	*	***

*Note: *** represent 0.1% level of significance, ** represent 1% level of significance & * represent 5% level of significance.*

Significant distinctions ($p<0.1$) were evident among treatments, particularly in root diameter. Compost manure + Boron exhibited the maximum root diameter (3.66cm), suggesting optimal soil conditions and nutrient availability, potentially influenced by weather dynamics. Genetic factors may also contribute, influencing the plant's inherent ability for robust root development. Goat manure + Boron, though effective, demonstrated a slightly smaller root diameter (2.97cm), possibly due to less comprehensive utilization of these factors. This finding aligns with previous research by Afrin et al. (2019). In contrast, the Control group showed the minimum root diameter (1.05cm), indicating suboptimal growth conditions likely attributed to the absence of specific treatments. Limited nutrient availability, lack of soil amendments, and genetic factors collectively contribute to restricted root development, resulting in a smaller observed root diameter. The overall mean root diameter at harvest was 2.35 cm, slightly lower than reported in prior research by Colombari et al. (2018) and Chukwu et al. (2022), which was (3.6 cm), emphasizing the role of chemical fertilizers and organic manures in enhancing root diameter.

Significant variations ($p<0.1$) were observed among treatments, particularly in fresh root weight. Compost manure + Boron exhibited the maximum fresh root weight (150g), signalling optimal conditions and nutrient availability, possibly influenced by climatic factors. Genetic factors might contribute to the observed differences, showcasing the plant's inherent capacity for robust root development. Following closely was Goat manure + Boron, with a fresh root weight of 114.83g, suggesting effective utilization of conditions, albeit slightly less than the top-performing treatment. Control group displayed the minimum fresh root weight (50.33g), indicating suboptimal growth conditions likely due to the absence of specific treatments. Limited nutrient availability, absence of soil amendments, and genetic factors collectively contribute to restricted root development, resulting in the observed smaller fresh root weight. The overall mean fresh root weight at harvest was 97.62g, representing the combined impact of treatments on enhancing root weight.

Significant differences ($p<0.1$) in root yield per plot were evident among treatments. Compost manure + Boron yielded the highest (9.6 kg), showcasing optimal conditions potentially influenced by climate, appropriate fertilizer dosage, and specific boron application. Genetic factors, including the choice of plant variety, likely contributed to the observed variations, emphasizing the inherent capacity for robust root development. The above results are almost similar to the findings recorded by Kiran et al. (2022) & Paul et al. (2022). Goat manure + Boron followed closely with a yield of 7.35 kg, which is also similar to the results demonstrated, suggesting effective utilization of environmental and cultural practices, albeit slightly lower than the top-performing treatment. In contrast, the Control group exhibited the lowest yield per plot (3.22 kg), emphasizing the importance of treatments in promoting root development. Insufficient nutrient availability, lack of soil amendments, and suboptimal cultural practices collectively contributed to the restricted root development in the Control group.

Table 5 – Effect of organic and inorganic fertilizers on yield parameters at 120DAS in carrot

Treatment	Reproductive parameters			
	RL (cm)	RD (cm)	FWR (gm)	RY (kg)
Control	8.22^{e}	1.05^{e}	50.33^{d}	3.22^{d}
Compost manure+ Boron	17.83^{a}	3.66^{a}	150^{a}	9.6^{a}
Poultry manure+ Boron	12.22^{c}	2.24^{cd}	90.67^{c}	5.80^{c}
Vermi compost+ Boron	12.31^{c}	1.99^{d}	87^{c}	5.57^{c}
NPK + Boron	10.82^{d}	2.03^{d}	87.33^{c}	5.59^{c}
Neem cake + Boron	13.10^{c}	2.53^{c}	103.17^{bc}	6.60^{bc}
Goat manure + Boron	15.13^{b}	2.97^{b}	114.83^{b}	7.35^{b}
Grand mean	12.80	2.35	97.62	6.24
SEM (±)	0.11	0.04	2.36	0.15
CV (%)	4.01	1.30	11.07	11.06
F- test	***	***	***	***

*Note: *** represents 0.1% level of significance, RL=Length of root, RD= Root Diameter, FWR= Fresh weight of root/ plot& RY= Root yield/plot.*

This is in parallel with the results presented in the study by Ahmad et al. (2016). Further, Adhikari et al. (2023) and Sangam et al. (2023) also reported that organic fertilizers can significantly induce the productivity of the crops. The overall mean yield per plot across treatments was 6.24 kg, reflecting the cumulative impact of climate, fertilizer application, variety selection, and cultural practices on root yield.

RESEARCH LIMITATION

One of the significant limitations of conducting fertilizer trials in carrots in hilly areas lies in the variability of soil conditions and topography across the terrain. Hilly regions often exhibit diverse soil compositions, slopes, and drainage patterns, which can significantly influence nutrient availability, uptake, and plant growth. Moreover, factors such as erosion and leaching may vary greatly within a relatively small geographical area, making it challenging to accurately assess the effectiveness of fertilization strategies. Additionally, the climatic conditions in hilly areas, including temperature fluctuations and precipitation patterns, can further complicate the interpretation of trial results, as they impact soil nutrient dynamics and plant responses. Hence, while fertilizer trials provide valuable insights, caution must be exercised in generalizing findings across hilly terrains due to the inherent complexity and variability of these environments.

CONCLUSION

The results showed significant differences in morphological and yield characteristics among all treatments compared to the control group. It is concluded that the application of Compost manure combined with Boron resulted in the highest growth and yield, followed by Goat manure combined with Boron, while the control group exhibited the lowest performance. Utilizing organic manures, specifically at a rate of 20 t/ha for compost manure, 15 t/ha for Goat manure, and 10 kg/ha for Borax, is recommended for enhancing both the quality and quantity of carrot production while mitigating soil boron deficiency. These findings emphasize the practical significance of organic manure application in optimizing carrot yield and soil health.

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