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Comparative studies of organic manure and chemical fertilizers in carrot (*Daucus carota* L.)

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Abstract

A field experiment was conducted during the 2022–23 and 2023–24 at Horticultural Research Farm, Ch. Chhotu Ram (P.G.) College, Muzaffarnagar, C.C.S university Meerut (U.P.), to study the comparative effect of organic and chemical fertilizers on growth and yield parameters of carrot (*Daucus carota* L.) cv. Nantes. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 12 treatments and 3 replications, including combinations of recommended dose of fertilizers (RDF), farmyard manure (FYM), and vermicompost. Results revealed that the application of 80% RDF + Vermicompost @ 3 t/ha (T_6) significantly outperformed other treatments in terms of plant height, number of leaves, leaf length, fresh plant weight, root length and yield. T_6 recorded the maximum plant height (44.19 cm and 45.64 cm), number of leaves (15.30 and 15.76), root length (20.87 cm and 22.21 cm) and highest yield (146.46 and 150.23 q/ha) in 2022–23 and 2023–24, respectively. The enhanced performance under T_6 is attributed to the synergistic effects of chemical and organic nutrient sources, improved nutrient availability and enhanced soil health and microbial activity. These findings underscore the potential of integrated nutrients management, particularly the combination of reduced chemical inputs with vermicompost, in improving carrot productivity sustainably.

Keywords: Carrot, Growth, INM, Yield and Vermicompost.

Introduction

Carrot (*Daucus carota* L.) is one of the most widely consumed root vegetables globally due to its rich nutritional profile, including high levels of beta-carotene, fiber, vitamins and antioxidants (Ahmad *et al.,* 2021). The demand for high-quality carrots has increased significantly, necessitating efficient agronomic practices to maximize yield and improve nutritional quality. One of the most crucial aspects of carrot production is soil fertility management, which significantly influences growth, yield, and overall plant health (Kumar *et al.,* 2020). Soil fertility is typically maintained using either organic or chemical fertilizers, both of which have distinct effects on soil health and crop productivity. Organic fertilizers, derived from plant and animal residues, enhance soil organic matter content, improve microbial activity and provide a slow and sustained nutrient release (Peyvast *et al*., 2019). In contrast, chemical fertilizers provide readily available nutrients that promote rapid plant growth but may lead to soil degradation, nutrient leaching and environmental pollution when misused (Singh *et al*., 2022). The comparative effectiveness of these fertilizers in carrot production remains a topic of interest among researchers and farmers alike. Carrots are a significant vegetable crop cultivated worldwide, particularly in temperate and subtropical regions. The Nantes cultivar is highly favoured for its sweet taste, smooth texture, and high market de-

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mand. Carrots contribute substantially to human nutrition and are used in various food products, including juices, salads and processed foods (Hassan *et al.*, 2018). The economic importance of carrot production further underscores the need for sustainable agricultural practices that ensure high yield and quality while maintaining soil health. Fertilization is one of the most critical factors influencing plant growth, development, and yield. Organic and chemical fertilizers differ in their composition, nutrient release patterns and overall impact on soil and plant health (Sharma and Gupta, 2021). While organic fertilizers improve soil structure and promote beneficial microbial communities, they often have lower nutrient concentrations and slower nutrient release rates compared to chemical fertilizers (Zhou *et al*., 2020).

Chemical fertilizers, on the other hand, provide immediate nutrient availability but may negatively impact soil microbial diversity and long-term soil fertility (Rahman *et al.*, 2019). Several studies have examined the effects of different fertilization strategies on carrot growth and yield. Research has shown that balanced fertilization significantly enhances root development, biomass accumulation and carotenoid content in carrots (Mahmood *et al*., 2017). However, excessive reliance on chemical fertilizers may lead to issues such as nitrate accumulation, reduced soil organic matter, and increased susceptibility to pests and diseases (Jat *et al*., 2021). Comparative studies on organic and chemical fertilizers in root vegetables, including carrots, have yielded varied results. Some studies suggest that organic fertilizers lead to better soil structure and long-term sustainability, while others highlight the immediate productivity benefits of chemical fertilizers (Ali *et al*., 2019). The use of compost, farmyard manure, and biofertilizers has been linked to improved soil aeration, moisture retention, and enhanced microbial activity, which contribute to steady nutrient uptake and growth (Goyal *et al.*, 2022). Conversely, synthetic fertilizers such as urea, ammonium nitrate, and phosphate-based compounds have been found to boost yield but may degrade soil quality over time (Panda *et al.*, 2020). The effectiveness of these fertilization strategies also depends on factors such as soil type, climate conditions, and crop variety. Research on carrots specifically has indicated that a combination of organic and inorganic fertilizers can maximize both yield and soil health benefits (Tiwari *et al*., 2018). However, there is still a need for more region-specific studies to determine the best fertilization strategies for different agro-climatic conditions.

The environmental impact of fertilization practices is a growing concern in modern agriculture. Organic fertilizers are often promoted as environmentally friendly due to their ability to enhance soil biodiversity and reduce chemical runoff into water bodies (Choudhary *et al*. 2021). In contrast, excessive use of chemical fertilizers contributes to greenhouse gas emissions, soil acidification, and water contamination (Lal *et al*., 2019). The economic aspect of fertilizer use is also significant, as organic fertilizers can be cost-effective in the long run by improving soil fertility and reducing dependency on synthetic inputs (Reddy *et al.*, 2023). However, their initial lower nutrient availability and application challenges may pose limitations compared to readily available chemical fertilizers. For instance, studies on chemical fertilizers frequently highlight their ability to rapidly increase nutrient availability, leading to enhanced root development and higher yields in carrot production. However, concerns about long-term soil degradation, reduced microbial diversity, and environmental pollution persist (Verma *et al.*, 2021).

Conversely, research on organic fertilizers often underscores their benefits in improving soil structure, microbial activity and long-term fertility. Yet, challenges such as slower nutrient release, inconsistent availability, and potential yield limitations compared to synthetic inputs remain underexplored in a comparative context. Furthermore, the economic feasibility of organic versus chemical fertilization strategies is crucial for farmers' decision-making. While organic fertilizers may reduce input costs and promote sustainable farming, their immediate yield impact and labour-intensive application methods may deter widespread adoption. On the other hand, chemical fertilizers, though efficient, may lead to increased dependency and fluctuating costs. Thus, a comprehensive study that examines the growth per-

formance, soil health implications and economic viability of organic and chemical fertilizers under diverse agro-climatic conditions for Nantes cultivar of carrot is necessary. Such research would bridge the existing knowledge gap and provide practical recommendations for sustainable and efficient carrot cultivation.

Materials and Method

The field experiment was conducted during thetwo consecutive seasons 2022-23 and 2023-24 at Horticultural Chaudhary Chhotu Ram (P.G.) College, Muzaffarnagar (U.P.) The experiment was laid out into Randomized Complete Block Design (RCBD) with 3 replications with 12 treatments *viz.* T_1= Control (no fertilizers), T_2= RDF 100%(NPK) Kg/ha, T_3= Farm yard manure @ 24 tonnes/ha, T4= Vermicompost @ 6 tonnes/ha T5= 80%RDF + Farm yard manure @ 12tonnes/ha, T_6= 80%RDF + Vermicompost @ 3tonnes/ha, T_7= 80%RDF + Vermicompost @ 3tonnes/ha, T8 = 60%RDF + Vermicompost @ 1.5tonnes/ha, T_9= 40%RDF + Farm yard manure @ 16 tonnes/ha, T10 =40%RDF + Vermi compost @ 4 tonnes, T_{11}= 20%RDF + Farm yard manure @ 20 tonnes and T_{12} = 20%RDF + Vermi compost @ 4 tonnes. Standard culture practices recommended for carrot were followed uniformly in all experimental plots.

Total ten observation recorded **p**lant height, number of leaves per plant, leaf length, leaf width, fresh weight of plant, dry weight of plant, root length, fresh weight of root, dry and weight of root and yield per hectare.

Results and Discussion

Plant Height

The application of integrated nutrient management significantly influenced plant height during both years of the experiment. Treatment T_6 (80% RDF + Vermicompost @ 3 t/ha) recorded the maximum plant height (44.19 cm and 45.64 cm in 2022–23 and 2023–24, respectively), followed by T_5 (80% RDF + FYM @ 12 t/ha) and T3 (FYM @ 24 t/ha), (Table 1). The lowest plant height was observed in the control. The increase in plant height under T_6 can be attributed to the synergistic effect of inorganic nutrients and the gradual release of nutrients from vermicompost, enhancing nutrient availability, microbial activity and soil health (Chatterjee *et al*. 2014; Singh *et al*., 2020). Vermicompost is rich in plant growth regulators and enzymes, which stimulate cell elongation and division.

Number of Leaves per Plant

Treatment T_6 also produced the highest number of leaves per plant (15.30 and 15.76), indicating a positive influence on vegetative growth. FYM-based treatments T_5 and T_3 followed, while control plots showed the lowest leaf count (Table, 1). Improved leaf production in T_6 may be due to the enhanced supply of macro and micronutrients and better soil aeration provided by vermicompost. According to Kale *et al*., (2005), vermicompost enhances the physiological functions and photosynthetic efficiency of plants, resulting in increased leaf number.

Leaf Length and Width

Leaf length was significantly greater in T_6 (34.62 cm and 35.86 cm), while leaf width was highest in T5 (14.13 cm and 15.76 cm). This reflects the better growth conditions and nutrient uptake under integrated nutrient management systems. The increase in leaf dimensions under these treatments may be attributed to improved nitrogen availability, which promotes chlorophyll synthesis and cell expansion (Kumar *et al*., 2019). FYM and vermicompost also enhance the moisture-holding capacity and porosity of the soil, supporting leaf development (Table 1).

Fresh and Dry Weight of Plant

T_6 recorded the highest fresh plant weight (218.99 g and 220.43 g), indicating superior biomass accumulation, followed by T_5 and T3. Dry weight was, however, highest in T_5 (19.14 g and 20.69 g), followed by T_7 and T_3 (Table 1). This suggested that FYM contributes to biomass density and carbon fixation efficiency. FYM's slow nutrient release supports sustained growth (Patel *et al*., 2018). The high microbial activity associated with organic manures also enhances root and shoot biomass (Ramesh *et al*., 2014).

Root Length

T_6 consistently showed the best performance

Table 1. Study the comparative effect of organic and chemical fertilizers on growth and yield parameters of carrot (*Daucus carota* L.) cv. Nantes

Parameters / Treatments	Plant Height (cm)		Number of Leaves per plant		Leaf Length (cm)		Leaf Width (cm)		Fresh weight of plant (g)	
	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
T_1= Control (no fertilizers)	34.41	35.87	10.41	10.87	24.62	25.87	10.78	9.77	158.99	160.43
T_2= RDF 100%(NPK) Kg/ha	37.19	38.65	10.53	10.99	28.29	29.54	10.99	12.00	188.99	190.43
T_3= Farm yard manure @ 24 tonnes/ha	38.30	39.76	11.52	11.98	29.73	30.98	11.34	12.21	195.87	197.32
T_4= Vermi compost @ 6 tonnes/ha	37.19	38.65	12.30	12.76	30.62	31.87	13.54	12.56	198.56	200.00
T_5= 80% RDF + Farm yard manure @ 12 tonnes/ha	41.41	42.87	13.97	14.42	32.86	34.11	14.13	14.76	213.99	215.43
T_6= 80% RDF + Vermi compost @ 3 tonnes/ha	44.19	45.64	15.30	15.76	34.62	35.86	12.56	15.35	218.99	220.43
T_7= 80% RDF + Vermi compost @ 3 tonnes/ha	38.30	39.76	13.30	13.76	31.29	32.54	12.68	13.78	204.09	205.54
T_8 = 60% RDF + Vermi compost @ 1.5tonnes/ha	39.30	40.76	10.99	11.44	31.97	33.21	10.28	13.90	208.77	210.21
T_9= 40%RDF + Farm yard manure @ 16 tonnes/ha	37.30	38.76	12.30	12.76	25.51	26.76	10.65	11.50	178.90	180.34
T_{10} = 40%RDF + Vermi compost @ 4 tonnes	36.41	37.8	10.41	10.87	26.40	27.65	8.78	11.87	183.88	185.32
T_{11}= 20%RDF + Farm yard manure @ 20 tonnes	35.41	36.86	13.3	13.76	25.51	26.76	9.23	10.00	163.98	165.43
T_{12} = 20%RDF + Vermi compost @ 4 tonnes	36.30	37.76	13.24	13.70	23.75	25.0	9.31	10.45	169.10	170.54
C.D.	2.01	1.50	0.38	0.46	1.49	1.12	1.68	1.38	7.78	9.49
SE(m)	0.68	0.50	0.13	0.15	0.50	0.38	0.53	0.43	2.64	3.21
SE(d)	0.96	0.71	0.18	0.22	0.71	0.54	0.7	0.62	3.73	4.55
C.V.	3.10	3.87	1.84	2.12	3.04	2.20	6.265	5.86	2.40	2.90

Parameters / Treatments	Dry weight of plant		Root length		Fresh weight of root		Dry weight of root		Yield per hectare	
	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
T_1= Control (no fertilizers)	16.33	17.88	11.09	12.43	47.53	50.32	8.66	10.00	77.11	80.87
T_2= RDF 100%(NPK) Kg/ha	16.97	18.52	14.95	16.29	45.43	48.22	12.98	14.32	118.45	122.21
T_3= Farm yard manure @ 24 tonnes/ha	17.22	18.77	15.98	17.31	47.42	50.21	14.64	15.98	130.22	133.98
T_4= Vermicompost @ 6 tonnes/ha	18.67	20.22	17.00	18.34	52.42	55.21	15.09	16.43	127.13	130.89
T_5= 80% RDF + Farm yard manure @ 12tonnes/ha	19.14	20.69	18.87	20.21	62.55	65.34	18.28	19.62	145.21	148.98
T_6= 80% RDF + Vermicompost @ 3 tonnes/ha	17.74	19.29	20.87	22.21	67.42	70.21	19.31	20.65	146.46	150.23
T_7= 80% RDF + Vermicompost @ 3 tonnes/ha	18.19	19.73	17.42	18.76	52.42	55.21	15.95	17.29	132.10	135.87
T_8 = 60% RDF + Vermicompost @ 1.5 tonnes/ha	15.38	16.93	17.98	19.32	57.32	60.11	17.20	18.54	138.88	142.65
T_9= 40% RDF + Farm yard manure @ 16 tonnes/ha	15.85	17.39	12.66	14.00	42.53	45.32	10.09	11.43	112.62	116.38
T_{10} = 40% RDF + Vermi compost @ 4 tonnes	13.98	15.53	13.66	15.00	43.53	46.32	10.98	12.32	116.56	120.32
T_{11}= 20% RDF + Farm yard manure @ 20 tonnes	14.46	16.00	11.54	12.88	41.64	44.43	8.98	10.32	108.66	112.43
T_{12} = 20% RDF + Vermi compost @ 4 tonnes	15.43	16.98	11.92	13.26	43.14	45.93	9.00	10.34	96.58	100.34
C.D.	0.628	0.796	0.765	0.875	2.250	2.478	0.694	0.691	5.777	5.741
SE(m)	0.213	0.270	0.259	0.296	0.764	0.834	0.235	0.234	1.957	1.945
SE(d)	0.301	0.381	0.367	0.419	1.081	1.179	0.332	0.331	2.768	2.750
C.V.	2.218	2.571	2.703	3.078	2.633	2.689	3.031	2.746	2.805	2.704

in terms of root length (20.87 and 22.21 cm), This implies that vermicompost significantly promotes root proliferation and thickness (Table 1). Improved root traits may be due to better aeration and structure of the rhizosphere in organically enriched soils (Bhattacharyya *et al.,* 2016). Vermicompost contains auxins and cytokinins, which promote root elongation and branching (Arancon *et al*., 2004).

Fresh weight of root

Among the various treatment combinations treatment T_6= 80%RDF + Vermicompost @ 3tonnes/ha produce maximum fresh weight (19.31 and 20.65 g) during both year of trail 2022-23 and 2023-24 respectively. It was followed by treatment T_5(18.28 and 19.62 g) and T_8(17.20 and 18.54g). Minimum fresh weight was noticed in control (8.66 and 10.00 g). These findings are accordance with Kumar *et al.,* (2019) (Table 1).

Dry weight of root

Among the various treatment combinations treatment T_6 = 80%RDF + Vermicompost @ 3 tonnes/ha produce maximum fresh weight (67.42 and 70.21 g) during both year of trail 2022-23 and 2023-24 respectively. It was followed by treatment T_5 (62.55 and 65.34g) and T_8 (57.32 and 50.32g). Minimum fresh weight was noticed in control (47.53 and 50.32 g). These findings are accordance with Kumar *et al.,* (2019), (Table 1).

Yield (q/ha)

Yield was maximized in T_6 (146.46 and 150.23 q/ha), followed closely by T_5 and T_8. The increase in yield is likely a consequence of enhanced vegetative growth, efficient nutrient uptake, and improved root health, (Table 1). Integrated nutrient management (INM) strategies increase nutrient-use efficiency and reduce nutrient losses, thus boosting yield potential (Das *et al.,* 2017). The synergy between RDF and organic manures ensures continuous nutrient availability throughout the crop cycle.

Conclusion

The present study clearly demonstrates the positive impact of integrated nutrient management (INM) on the growth, biomass accumulation, root development, and yield of the crop across two consecutive years. Among the various treatment combinations, T6 (80% RDF + Vermicompost @ 3 t/ha) consistently outperformed other treatments by recording the highest values for plant height, number of leaves, leaf dimensions, root length, root biomass, and overall yield. The superior performance of T6 can be attributed to the synergistic effects of inorganic fertilizers and vermicompost, which enhance nutrient availability, improve soil physical properties, and stimulate microbial and enzymatic activity in the rhizosphere.

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